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EFFECTS OF FUTURES TRADING ON PRICE PERFORMANCE IN THE CASH ONION MARKET, 1930-68

U.S. DEPARTMENT OF AGRICULTURE • ECONOMIC RESEARCH SERVICE

ABSTRACT

Farm, shipping point, and wholesale onion prices on both a weekly and a monthly basis were used to assess the impact of trading in onion futures contracts on the performance of cash onion prices. A secondary objective was to develop appropriate statistical measures of price performance. The years from 1930 to 1968, excluding World War II, were used in the analysis. This period was characterized sequentially by a subperiod of no futures trading, one with active futures trading, and one with no trading. Primary concern was with Chicago and Michigan onion prices but other markets were considered. Price variation over time, including year-to-year, within-season, seasonal, and within-month price changes, and price variation over space were considered. Evaluation of the results from all the analyses in total support the general conclusion that there was no significant change in price performance over the entire period. Several measures of price performance are presented, with a theoretical basis for their use and methods of interpreting them.

Keywords: Marketing, onions, prices, price performance, futures trading, price analysis.

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SUMMARY

A shift in price performance (level and variability of prices) in the cash onion market apparently occurred between 1930-40 and 1946-57, the latter period characterized by an active futures market in onion contracts. However, because World War II occurred during the intervening years, it was not possible to immediately conclude that the observed change was caused by the introduction of futures trading. In addition, an analysis of various measures of price performance revealed that no change occurred from 1959 to 1967, the 9 crop years following the congressional ban on futures trading. If the crop years of 1931, a somewhat unique year during the entire period, and 1958, the transitional year from active futures trading, are eliminated, the analysis would support the general conclusion that there was no significant shift in price performance in the cash onion market during the entire period from 1930 to 1968.

Aggregate within-season price variation differed among markets and over time, with greater variation occurring at shipping point than at wholesale. However, if the perfectly competitive market is used as a reference point, price variation did not appear excessive, particularly for the period following World War II.

One component of aggregate within-season price variation is price change associated with storage cost, referred to here as price seasonality. Two previous studies concluded that the introduction of the futures market resulted in a flatter seasonal pattern in cash onion prices. However, an updating of these two studies showed that, with the exception of 1958, the seasonal pattern remained unchanged following the ban on futures trading. Further, if the 1931 crop year is omitted from the analysis then it is difficult to support the hypothesis that there was a significant shift in the seasonal pattern of cash onion prices during the entire period. This applied whether using the farm price or an f.o.b. shipping point price and whether using monthly or weekly price indexes.

A second component of aggregate within-season variation is the monthly price range, a statistical measure used to assess the impact of the price discovery process. A substantial reduction in within-month price variation occurred between the period of no futures trading and the period of substantial trading; no significant change occurred following the ban on futures trading. This suggests that whatever caused the shift in price performance from the first to the second period persisted through the third period. However, if 1931 is omitted, a major portion of the observed difference between the first and second periods is eliminated. Consequently, it is not clear that there was, in fact, a significant shift in within-month price variation.

The perfectly competitive market in space was used as a framework for analyzing price relations among spatially separated markets. Overall, the results were mixed and do not lend themselves to general and defensible conclusions. The source of this result lay in the problem of data pooling: When data for all years were pooled, the analysis indicated a deviance of price performance from the competitive norm; with a smaller degree of aggregation, performance appeared to approach the norm. As a minimum, it is clear that the nature of price performance over space was changing but it is not at all clear what effect, if any, the presence or absence of the futures market had on that performance.

EFFECTS OF FUTURES TRADING ON PRICE PERFORMANCE IN THE CASH ONION MARKET, 1930-68

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CHAPTER 1. PERSPECTIVE

A question of considerable interest to students of agricultural marketing relates to the impact of a futures market on the performance of the pricing system of the commodity involved. This question is becoming more and more important as the structure of cash markets is undergoing change brought about by such things as improved transportation and communication systems, more extensive use of specification buying, increasing reliance on bargaining, and the use of such institutions as marketing orders. These structural shifts raise serious questions concerning the efficacy of the traditional pricing mechanism of these commodities. Simultaneously with these changes, futures markets have been playing an increasing role in the marketing of farm commodities, both in terms of trading activity in established futures markets and in terms of new futures markets opening up. Thus, it is of paramount importance to continue the attempt to assess the role of futures markets in pricing performance.

This assessment has been somewhat difficult in the past because of the lack of a well-developed theoretical framework and the difficulty of doing empirical research. These mutually reinforcing problems have resulted in the inability of students of agricultural markets to answer specific questions and charges concerning the contributions of futures markets to pricing performance. Only in very recent years has a body of empirical research begun to emerge which is providing initial insights into some of the answers. Progress along these lines is needed and welcome. This report will, hopefully, make a modest contribution to this development.

The research considered in this report involves an assessment of the impact of futures trading on the cash onion market. Of the commodities that have been involved with futures trading, the history of the onion market makes it of special interest to students of price performance. The period since 1930 may be considered as three subperiods: From 1930 to World War II, there was an active and well-developed cash market for onions but there was no futures market; for approximately 10 years following the war there was, in addition to the cash market, an active futures market; finally, futures trading in onions was banned in 1958 by congressional action and there has been no trading in onion futures contracts since that time. Thus, one may study price behavior in this cash market during three distinct periods—no futures trading, active futures trading, and no futures trading. This quasi-laboratory situation is somewhat unique for the empirical analysis of futures markets in agricultural commodities. For some commodities, such as livestock products, it is possible to study a market before and during futures trading, since these markets have come into existence in recent years. For others, however, such as feed grains, it is not possible to meaningfully study periods without futures trading because these commodities have had active futures markets for many years.

The contribution of this report is twofold. First, and perhaps of primary importance, it serves as an educational document. An attempt is made to reveal the complexity of evaluating price performance in an actual cash market and, at the same time, to indicate some of the characteristics of price relations over time and over space that should be considered in such an evaluation. Second, an analysis of the actual performance of cash onion prices from 1930 to 1968 is presented.

Format of Report

The remainder of this chapter delineates the scope of the study and discusses some fundamental considerations necessary to provide a perspective for evaluating the conclusion drawn. The next chapter summarizes the results of the research and presents the conclusions drawn with respect to price performance in the cash onion market. The remaining chapters present the research results that provide the basis for these conclusions.

Definition of the Onion Market

Seasonal Crops

Since onions are grown seasonally in many regions throughout the United States and are sold in a national market, a study of the "onion market" should necessarily reflect the total situation. However, since the ultimate purpose of the research relates to the onion futures market, it is possible to restrict the scope of the study. There are four seasonal onion crops: early spring, grown primarily in Texas; late spring, grown in Texas and California; early summer, grown in Texas and New Mexico; and late summer, grown in the northern tier of the United States. The first three of these seasonal crops are harvested in the Southern States during warm weather and must move to market as soon as they are harvested. On the other hand, by taking advantage of the cool weather following the harvest of late summer onions in the Northern States it is possible to store them for subsequent sale for up to 7 months.

This late summer or storage crop provided the basis for the futures trading in onions and, thus, the price performance for this crop received the major emphasis in the current research. However, it was appropriate from time to time to consider the early spring, or Texas crop since this crop often competes in the market with remaining storage stocks from the previous late summer crop. Even in years when the two crops are not in direct competition, expectations concerning the magnitude of the Texas crop and the time of its arrival on the market may have a perceptible impact on the market price of the late summer crop toward the end of the storage season.

Geographic Scope of the Market

In the context of the late summer crop, a comprehensive research endeavor would encompass the complex interrelations among the supply and demand conditions in all of the several producing regions. However, it was possible to reduce the scope of geographic coverage to a considerable extent. There is reason to believe that historically the Rocky Mountain range has served as an effective dividing line creating a certain degree of independence between the Eastern and Western United States with respect to the onion market. To the extent that this is true, one sector of the market may be studied without explicit consideration of the other sector, and this approach has been adopted herein.

For current purposes, attention focuses primarily on cash prices in Michigan and Chicago. This recognizes that delivery on the onion futures contract was at Chicago and that Michigan has historically been a major supplier of the Chicago market. Consequently, the impact of market forces should be reflected in the performance of price at these two points in the marketing system. In addition, it is of considerable interest to investigate the relationship between Michigan and New York prices to determine the nature of price performance over space. Since the onions produced in these separate regions must be priced in a national market, it seems reasonable to expect an interdependency to exist between the prices received in the two regions.

Price Series Used

There remains the question of what specific price series to use in the analysis. As students of agricultural prices are painfully aware, there is no such thing as only one price for any commodity; rather, there is an array of prices, each relating to some alternative definition of the commodity of interest. For the current study, there are two such prices. One is the price received by farmers, sometimes referred to as the farm price, and the other is a price reported on an f.o.b. shipping point basis. The reported farm price is derived by dividing the total revenue from all sales of the commodity by the total quantity sold. As a result, it is a composite price reflecting not only basic supply and demand conditions in the market but also differences in grade and quality, differences in selling methods, differences in containers and packaging, and so on. The problem with using this price in a time-series analysis is that its value may change from one year to the next, not because of changes in basic supply and demand forces, but because of a shift in the distribution of the total crop by grade or because a new type of packaging material is introduced. In other words, the "commodity" represented by this price is not constant over time.

To circumvent this problem, it is desirable to use an f.o.b. shipping point price since such a price typically refers to a specific grade and quantity for which the definition changes little, if any, from year to year. To the extent that this is true, year-to-year changes in this price should be more reflective of changes in the market forces one is attempting to assess. In addition, this price series corresponds more closely to the futures market price series than does the farm price. For these reasons, this study used f.o.b. shipping point prices for Michigan and for New York. For Chicago, the wholesale price for Michigan onions was used. In several places, comparisons involved prices at other shipping points and in other wholesale markets. All prices are in units of 50-pound sacks.

Development of Continuous Price Series

As in most empirical research, serious data problems were encountered. Of primary concern was the lack of consistency in the price series to be used, both in terms of reporting base (e.g., for some years the price may be quoted on the basis of at least 70 percent No. 1's, while for other years the base may be 60 percent) and in terms of missing observations. For most of the comparisons made, weekly prices were used and were calculated by taking the midpoint of the weekly price ranges reported in various issues of the annual reports filed by USDA's market news service. For some of the price series, data for entire years were not available. For others, there were weeks during which, for some reason or another, prices were not reported. In an attempt to have as complete a series as possible, several adjustments were made. For example, in any case where just 1 week was missing, a price for that week was entered by taking the midpoint of the prices reported for the preceding and following weeks. The one exception to this rule was when a gap of 2 or more weeks occurred following the first reported price for the shipping season or preceding the last reported price for the shipping season. In that case, the actual length of the shipping season was changed by dropping the first or last reported price, whichever was appropriate.

Deflation of Prices

When studying the price of an agricultural commodity, such as onions, over a long period of time, it is important to distinguish between two sets of forces which generate price change. One set of forces affects the general price level for all farm commodities. Population growth, changes in income levels, general business conditions, and international conditions are suggestive of general forces at work in the economy that would affect the level of all prices. The other set of forces giving rise to price change is unique to a particular commodity, onions in this case. Changes in supply of onions from year to year, development of new technology for harvesting and storing onions, other cost changes, and changes in consumers' dietary habits, for example, would be viewed as forces essentially unique to the onion market.

From the standpoint of empirical analysis, this means that the analyst must contend with both the general and the unique forces if he is to explain the historical course of observed price. Since this study was concerned only with the unique factors, it was necessary to adjust cash onion prices to remove the effect of the general economic forces. This was accomplished by dividing each price by an appropriate price index for all commodities. This deflation procedure transforms observed prices into "real" prices, i.e., prices adjusted for the general price level. In the following chapters, actual onion prices have been deflated by the Index of Prices Received by Farmers, All Commodities, 1910-14 = 100.

Price Variation and Time-Unit of Observation

The definition of the appropriate time-unit of observation for assessing price performance can be crucial, because conclusions concerning the adequacy of performance may differ depending on whether one considers daily, weekly, monthly, or long-term price change. The importance of recognizing the time-unit of observation cannot be overemphasized, because failure to recognize it can lead to considerable confusion. It is possible for one student of onion price performance to conclude that onion prices vary excessively and another to conclude that onion prices exhibit a remarkable stability over time. Such opposing points of view could simply reflect different time-units of observation used—one researcher might have considered day-to-day price variation and the other year-to-year variation.

This section discusses briefly the types of time movements recognized by students of commodity prices. The intent is to identify the various components of a time series of price and to suggest some of the reasons why these components may be observed. Methods for detecting and analyzing these components are not considered.[1]

Short-Term Variation

Price variation occurring within a trading day or from day to day is usually referred to as short-term variation.

[1] Interested readers are referred to F. L. Thomsen and R. J. Foote, *Agricultural Prices,* McGraw-Hill Book Company, 1952—especially chapter 17.

Such variation may be in response to changes in market conditions occurring during the period. For example, a sudden snowstorm in Michigan may retard the flow of onions into the Chicago wholesale market, resulting in a short-term increase in price which is quickly canceled once the usual flow of onions is resumed.

A slightly different cause of short-term price variation is a change in expected market conditions. The price of late summer onions during the latter part of the storage season is quite sensitive to conditions relating to the upcoming new crop from Texas. Consequently, changes in conditions which are expected to affect the quantity or quality of this crop, or the time that it is expected to arrive on the market, can have a marked impact on the short-term variation in the late summer onion price. Heavy and unexpected rain over the weekend during the Texas harvest could result in a substantial increase in onion price from Friday to Monday.

Regardless of the cause, short-term price variation is typically nonrepetitive. Under casual examination it may appear to be random. To the extent that it is caused by random events—in the sense of unpredictable events—it is random. For this reason, very little theorizing and very little empirical effort have been devoted to short-term price variation.

Seasonal Variation

Seasonal variation in a commodity price is usually associated with change in price from month to month. In fact, seasonality is a 12-month cycle which is repeated from one year to the next. Most agricultural commodities, because of their production and marketing characteristics, exhibit a seasonal price pattern. Seasonal shifts in demand may also generate a seasonal pattern in price.

For some annually produced commodities, such as late summer onions, the requirement that a certain portion of the crop be stored for sale while the commodity is not being harvested results in a definite seasonal price pattern that is associated with the cost of storage.

Annual Variation

Annual, or year-to-year, variation in the season average price is usually associated with crops that are harvested during a relatively short period only once during a calendar year, such as late summer onions. The observed change in price from one crop year to the next is basically a manifestation of changes in supply and demand. Since the demands for many agricultural commodities are relatively stable over time, these annual changes in price are normally associated with changes in supply, such as those that result from changes in weather conditions during the planting, growing, and harvesting periods.

Long-Run Trend

Long-run trend refers to a directional movement in price which persists over a long period of time. It is generally associated, in turn, with long-run, or persistent, trends in factors affecting the supply and demand of agricultural commodities. Continuous population growth and changes in technology are illustrative of factors giving rise to long-run trends in price.

Cycles

A cycle is defined as a regularly recurring movement in price which generally requires several years to complete the pattern. Such a price pattern is typically associated with the livestock sector, where the full effect of a decision to increase or decrease production is not reflected in market price until several years later. Cycles are not, in general, associated with annually produced commodities.

CHAPTER 2. OVERVIEW

The objective of this research project was to determine what effect trading in onion futures contracts had on the performance of price in the cash onion market. The general conclusion drawn was that it had no effect. As will be seen in the analyses discussed below, there was a marked shift in price performance in the cash onion market between 1930-40 and 1949-57, the latter period characterized by an active futures market in onion contracts. However, before imputing the cause of this change to the introduction of the futures market, it must be recognized that the intervening years encompassed World War II. Hence, it would be equally plausible to impute the change in performance to World War II. Indeed, that this may be a more acceptable observation is substantiated by the fact that, with the exception of isolated cases, all of the performance measures considered in the study strongly suggest that price performance during 1959-67, the 9 crop years following the congressional ban on futures trading, was not significantly different from that which existed during the period of active futures trading.

To put it differently, it appears that removal of futures trading in onions in 1958 did not result in the performance of the market reverting to the pre-futures-market situation. The forces that caused the shift from the prewar to the postwar period persisted for the 20-year period following the war, a period characterized by both active futures trading and not futures trading. Moreover, if the 1931 crop year is deleted in the calculation of performance statistics for 1930-40, as was done in many of the analyses below, it becomes difficult to reject the general conclusion that there was no change in price performance in the cash onion market from 1930 through 1967.

Some Observations on Research Problems

Research of the type undertaken here is extremely difficult for several reasons. While the existent body of price theory provides important insights into how agricultural markets perform and how market price is generated, it leaves much unanswered when considering a specific situation, such as the cash onion market.[2] Simplistically, the theory shows that the price of onions is determined by supply and demand. But what price should be used in a study of the onion market—the U.S. average price received by farmers, the Michigan f.o.b. price, the New York City wholesale price? What is the best empirical measure of onion supply—U. S. onion production, late summer production, the combined production of the major producing States? These are simply suggestive of the myriad of questions that had to be considered in this research project.

A second type of question involved a measurement problem. In the current study interest centers on price performance. This raised two specific questions: What is meant by "price performance," and how is it measured? Of perhaps greater importance, what does one use as a standard for assessing observed performance, however measured?

A third problem related to the time-unit of observation. Conventional price theory abstracts from calendar time, yet in the real world calendar time must be recognized. One may consider day-to-day price change, seasonal price change, trend, cycles and so on. This is an important question because the conclusions drawn concerning price performance are heavily dependent upon the type of price change being considered. As with the previous questions, price theory provides no guide as to which is the proper type of price change to study.

As a result of problems such as these, a great deal of experimentation and subjectivity is involved as the research endeavor unfolds. Practically, the researcher must consider alternative formulations of the problem, alternative ways of measuring the relevant variables, and, in the case at hand, alternative measures of price performance applied to various measures of calendar time. Only by careful assessment of the several results obtained is it possible to draw general conclusions with respect to the question at hand, but these conclusions necessarily contain a degree of subjectivity.

There was a second fundamental concern in the current research. The initiation of trading in onion futures contracts followed by termination of such trading would be defined as a structural change in the onion market—a change in the "environment" within which the price of onions is ultimately determined. The objective of the research was to determine what effect this structural change had on price performance in the cash market; the procedure was to compare observed price performance during periods with and without futures trading. To immediately impute observed changes in performance to the presence or absence of a futures market would be a questionable procedure because it is quite possible that during the period under investigation, 1930 to 1968, other changes in structure occurred, in addition to World War II.

In recognition of this concern, the question of the

[2] See chapter 3.

effect of the futures market on price performance was approached from two different bases. The research that is the subject of this report involved an assessment of observed price performance in the cash market and was effected by comparing periods with and without futures trading. A companion research project by the Economic Research Service attempted to determine whether other structural changes occurred in the onion market during the period under consideration. The next section reports on the general findings of that research.

Changes in Structure Other Than Futures Market[3]

To determine whether or not shifts in the structure of price-making forces in the cash onion market changed during 1930-68, two basic analyses were conducted: One considered the factors affecting the change in the season's average price from one year to the next and the other was concerned with factors causing price changes within a given year. For the year-to-year analysis, a regression equation, hypothesized to represent price-making forces in the onion market, was estimated separately for 1946-58 and 1959-69. Statistical tests applied to the coefficients obtained supported the hypothesis that the parameters of the structural variables were the same in the two periods—the first characterized by the presence of active trading in onion futures contracts and the second by the absence of such trading.

The analysis of within-season price change was beset with problems typically encountered in empirical research of this type: The percentage of observed price variation explained by the variables included in the analysis was very low; acceptable empirical measures of conceptually relevant variables were not readily available—weekly sales out of storage are a case in point; and, finally, the statistical results of the analysis were such that it was not possible to accept the hypothesis that the parameters of the equations were significantly different from zero.

A general conclusion emerging from this analysis is that the nature of the economic system generating changes in the season's average price was not affected by the termination of trading in onion futures contracts. Because of data problems, it was not possible to draw definitive conclusions with respect to the economic structure generating within-season price change.

[3] See Jesse, E. V., "Structure of Seasonal Supply and Demand in the Onion Market," U.S. Dept. Agr., Econ. Res. Serv., unpublished.

Year-to-Year and Within-Year Price Variation[4]

The first analysis of the current study considered two fundamental types of observed price variation: Changes in the level of prices from year to year, as measured by average prices for each year, and deviation of actual prices around these averages within the year. The first type of price variation may be referred to as trend analysis and the latter as seasonal variation. This latter may be viewed as a manifestation of two underlying market forces—price determination and price discovery.

Trend in Cash Prices

An analysis of the trend in cash onion prices was conducted for three points in the marketing system: Michigan and New York f.o.b. and Michigan wholesale in Chicago. All three price series moved in close conformity, as would be expected since all three markets are integral parts of the overall national market within which onions are priced. Using the Michigan f.o.b. price as representative, onion prices generally declined from 1930 to the mid-1950's. The rate of decline was quite precipitous from 1931 to 1936, dropping about $1 per sack. Following a low in 1936, price fluctuated rather steadily between $0.75 and $1 until 1945 when the downward trend was resumed. This decline persisted until 1954, with an exception during the early 1950's.[5] Prices appeared to bottom out during the early 1950's and since that time there appears to have been a rather small but persistent upward trend. Over all, the period from 1930 to 1967 may be characterized as one of declining prices from 1930 to the mid-1950's and one of stable to slightly rising prices since that time.

The introduction and subsequent cessation of trading in onion futures contracts appeared to have no perceptible impact on the general trend in cash prices. The major change in the nature of the trend occurred in the mid-1950's, approximately the middle of the period during which there was active futures trading. There is no clear evidence of a marked change in trend following the congressional ban on trading.

[4] See chapter 4.

[5] Prices of most farm commodities rose during this period due to the Korean conflict.

Within-Season Variation

One problem in assessing within-season price variation is knowing how to measure it empirically. In this study, the coefficient of variation was used as an aggregate measure. Heuristically, this is a number which expresses the variation in actual weekly prices as a percentage of the average price for the season. Since it is expressed in percentage terms it has the advantage of permitting direct comparison of variation from year to year for a particular price series, such as the Michigan f.o.b. shipping point price, to see whether the degree of variation has been changing over time. It also permits direct comparison of the variation in two different price series, such as the Michigan and New York f.o.b. price series. This, of course, is an aggregate measure and does not distinguish between variation associated with the expected seasonal pattern of onion prices and the variation associated with price discovery. These types of variation are discussed in subsequent sections.

The coefficient of variation was calculated for each year for the Michigan and New York f.o.b. and Chicago wholesale price series and plotted against time. There was considerable year-to-year variation in the magnitude of the coefficient of variation for all three price series. Because of this variation, there is no clear evidence of a trend in within-season price variation from 1930 to 1968. However, each successive peak was lower than the previous peak, while the extreme low values of the coefficient of variation were of the same order of magnitude over time. This suggests that a downward trend is in evidence; as a minimum, extreme degrees of within-season variation occurred with less frequency in the later years.

In addition, average coefficients of variation for the subperiods preceding, during, and following futures trading were calculated for the above three markets, as well as for wholesale prices in New York City for onions produced in Michigan, New York, and Texas and for the Texas f.o.b. price series. In all cases, except for the latter, the coefficient of variation was greater during the period preceding futures trading than in either of the other two periods, lending further support to the observation that there has been a tendency for within-season price variation to decrease over time. Further, the coefficients of variation averaged slightly higher during the period of active futures trading than during the period following. However, the magnitude of difference was smaller than between the first and second periods.

One problem with an evaluation of this type is that there is no standard against which to measure the calculated statistic. Is an observed coefficient of variation too high? Too low? What should it be? In response to this, a technique was developed which drew upon the theory of the perfectly competitive market to provide a statistic which would indicate what the within-season price variation would be if the market were operating under perfectly competitive conditions. Such a statistic was calculated yearly for the Michigan f.o.b. price series and was compared with the respective computed coefficients of variation.

This analysis clearly revealed that the onion market was becoming more competitive over time, that is, the degree of within-season price variation was becoming more nearly equal to that which would be predicted on the basis of the perfectly competitive market. A summary statistic, expressing observed variability as a percentage of predicted variability, was computed for the three time periods. During 1930-40, the value of this statistic was 1.9, indicating that the within-season price variation was about twice that which would have been predicted if the market had been operating under competitive conditions. Comparable averages for 1949-57 and 1959-67—periods of active futures trading and no futures trading—were 1.4 and 1.3 respectively. Thus, the performance appeared, on the average, to remain unchanged following cessation of futures trading in onions. However, when considering the individual years within each of the two time periods, there was some tendency for smaller values of this statistic to occur with a higher frequency in the latter period.

Seasonality in Onion Prices[6]

Commodities, such as late summer onions, that are harvested during a relatively short period and stored for sale during later periods normally exhibit a seasonal price pattern. Such a pattern is assumed to be invariant, or reasonably so, over time and is primarily a reflection of the costs incurred in carrying the commodity through time. The question of interest here is the effect that the futures market had on the seasonal pattern of onion prices.

In a paper published in 1960, H. Working, after carefully studying the seasonals in onion prices, for both the U.S. average farm price and for the western Michigan price to growers, concluded that the onion futures market had had a definite impact on the seasonal pattern.[7] Specifically, he showed that during futures trading the price during the earlier part of the season tended to be higher and the price in the latter part of the

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[6] See chapter 5.

[7] Working, H., "Price Effects of Futures Trading," Food Res. Inst. Studies, Stanford Univ., Vol. I, No. 1, Feb. 1960.

season tended to be lower than before the initiation of futures trading. To put it another way, prices tended to rise less seasonally during futures than before. He imputed this change to an improved efficiency in the cash market brought about by the presence of the futures market.

R. Gray extended this analysis in a paper published in 1963 by considering what had happened to the seasonal pattern following the ban on futures trading.[8] He came to the conclusion that the seasonal pattern had reverted to that existing prior to the initiation of trading. The implied conclusion is that the ban on futures trading resulted in introducing an inefficiency into the market.

In the current study, the work of these two researchers was updated by including data for an additional 7 crop years. The same procedures were followed in computing the seasonals for the monthly price series in order that the results would be comparable with the previous work cited above.

The result of updating these two studies by utilizing the more recent price data strongly suggests that, with the exception of 1958 which may be viewed as a transitional year,[9] the seasonal pattern of onion prices has remained unchanged since the ban on futures trading. The same conclusion seems to apply whether using the farm price or an f.o.b. shipping point price and whether using monthly or weekly price indexes.

If one considers the entire period from 1930 to 1968, which sequentially encompasses a period of no futures trading, substantial futures trading, and no futures, the general conclusion would be that the average seasonal price rise during the first period was substantially greater than during the latter two periods and that the average seasonal price rise during the latter two periods was the same. In other words, a decided shift in the structure of seasonality occurred between the first and second periods which persisted during the third period. However, if the seasonal index for the first period, 1930-40, is calculated omitting 1931, a year somewhat unique during the entire period, it is not so obvious that such a structural shift did, in fact, occur during the period.

A potential source of weakness in analyses of the type just described is that they rely on averages, hence there may be significant shifts occurring that are hidden by the averaging process. It is possible, for example, that such an index could show a strong seasonal pattern in prices even though the typical situation were one of little or no change. In an attempt to determine if this might be the case for onion prices, an analysis was undertaken to determine if there had been any significant trend in the seasonals themselves. One would be interested in determining, for example, if the September price had tended to rise relative to the season's average, if the December price had tended to decline relative to the season's average, and so on.

An analysis of each year from 1949 to 1968 strongly suggests that there has been no overall tendency for price in any particular month to persistently increase or decrease relative to the season's average price. In other words, there is no apparent trend in the seasonals, even though substantial year-to-year variation is evident. Price during the latter 2 months of the storage season, March in particular, has varied considerably with respect to the annual average. This variation was offset during September-November: When the March price is relatively high the early season price is relatively low, and vice versa, as it would have to be by virtue of the method used to calculate the seasonals. However, the observation made above is relevant here, namely, there is no apparent long-run trend in seasonals.

Within-Month Price Variation[10]

The previous analyses were concerned with price variation from month to month or from week to week. An alternative type of price variation is within-month price variation. This type of price variation is used here as an empirical measure of variation associated with the process of price discovery that is encountered in the onion market.

The concept of price discovery is associated with the real-world phenomenon of price forecasting, an activity in which all farmers and merchants participate as they move the onion crop from the point of primary production to the final consumer. For late summer, or storage, onions, price forecasting is difficult because of the uncertainty related to the size and timing of the Texas onion crop that typically competes with late summer onions during the latter part of the storage season. The need for farmers and merchants to correctly forecast the late season price is a prime requisite if the proper balance between the availability of storage onions and new-crop onions is to be achieved. Because of incomplete and inaccurate market information, it is clear that errors in price forecasting may occur. When they do, the consequence is likely to be a sharp readjustment in price at the end of the season as attempts are made to rectify the forecast error made earlier. For the current

[8] Gray, R., "Onions Revisited," Jour. Farm Econ., Vol. 45, No. 2, May 1963.

[9] The ban on trading was passed in 1958; it became effective in 1959.

[10] See chapter 6.

analysis, it was assumed that this type of adjustment is reflected by the monthly price range.

This raises the question concerning the impact that a futures market would have on the price discovery process. It has been suggested that a futures market would make this process more efficient, in the sense that less dramatic price adjustments would be required to effect the proper balancing of supply and demand during the storage season. In practical terms, this means that the observed monthly price ranges should be smaller during a period of futures trading than during a period of no futures trading. This line of reasoning provided the framework within which the monthly price ranges for the Michigan f.o.b. cash onion prices for 1930-68 were analyzed.

A comparison of the average price ranges, by months, among the three periods revealed that, in general, the price range for any particular month was higher during the first period (prior to futures trading) than during the second period (substantial futures trading) and the third period (following the ban on futures trading). In addition, the increase in the average range from month to month during the storage season was greater in the first period. It can be shown, however, that the 1930-40 averages were heavily influenced by 1931. A comparison of the second and third periods showed that they differed but little with regard to both the average value and to the seasonal increase.

A comparison of the variation of actual price ranges about their respective averages revealed essentially the same pattern. Variation was considerably larger in the first period than in either of the other two periods. However, the use of this variation in the context of a statistical test revealed that, while marked differences occurred, the probability is quite high that they could have resulted simply by chance alone.

A final analysis considered the distribution of price ranges, both overall and on a seasonal basis. Again the same pattern was observed. Larger values occurred with a higher frequency during the first period and lower values occurred with a lower frequency. This appeared to be true overall as well as on the seasonal basis. The distributions between the second and third periods again seemed to be quite similar.

To the extent that a valid generalization can be drawn from the comparisons made in this analysis, it would be that a very marked shift in the degree of within-month price variation occurred between the early period of no futures trading and the following period of substantial futures trading. This, in itself, might suggest that the shift was a consequence of introducing this market. Since the result was a reduction in the amount of price adjustment occurring within the various months of the marketing season, one might be tempted to conclude that the futures market had a salutary effect on the cash onion market. However, the comparisons of the second period with the period following the ban on futures trading in onions suggested that there was no difference between them. Apparently whatever caused the shift in price performance, as measured by the monthly price range, between the first and second periods persisted throughout the third period.[11]

Price Performance Over Space[12]

The analyses considered to this point have focused on the performance of price over time. Another question relating to a market is how price performs over space. More specifically, interest centers on the price relationships that exist among markets separated by space.

The model of the perfectly competitive market in space was used as a framework for investigating the relationships among onion prices at different points within the onion marketing system. In the context of a regression equation, this theory predicts that the regression coefficient, which shows how much one price changes in response to a change in another price, would have a value of 1.00. In addition, the theory suggests that the correlation coefficient, which is a measure of the degree to which the two prices move together over time, would be close to 1.00, indicating a high correlation in their movement. Using these as the evaluative criteria, regression equations were estimated using prices at different points within the onion marketing system and involving differing degrees of data pooling.

The first equations involved seven different market comparisons and were based on data pooled for the entire period. For four of the seven comparisons, the confidence interval failed to include the value of 1.00. In two of these four cases—Michigan f.o.b. vs. Michigan, Chicago wholesale, and New York f.o.b. vs. New York, New York City wholesale—the coefficient was larger than the expected value of 1.00. For the other two cases—the Michigan wholesale prices in Chicago and New York City, and Texas f.o.b. vs. Texas, New York City wholesale—the coefficients were less than 1.00. In the former cases, an increase of $1 at wholesale resulted in more than a $1 increase in price at the respective shipping points. A $1 increase in the wholesale price for

[11] However, as in the seasonal analysis, if the 1931 crop year is omitted from the computations it would be possible to support the hypothesis that there was no significant change in the magnitude of the monthly price range from 1930 to 1968.

[12] See chapters 8 and 9.

Michigan onions in New York City was associated with a smaller increase in the wholesale price for Michigan onions in Chicago, on the average, over the period. Finally, a $1 increase in the wholesale price for Texas onions in New York City was associated with a smaller increase in the f.o.b. price in Texas.

A second set of equations involved the same market comparisons but pooled the years into three separate periods—before futures trading, during futures trading, and following futures trading. A definite pattern emerged. For five of the seven comparisons, the regression coefficient had a value of 1.00 during futures trading but not during either of the other two periods. Four of the five were characterized by a coefficient greater than 1.00 prior to futures trading, equal to 1.00 during futures trading, and less than 1.00 following futures trading. In addition, there was a definite tendency for the correlation coefficient, which measures the degree of association in price movement over time, to decrease in each successive time period.

The third set of equations involved the Michigan f.o.b. price with the Chicago wholesale price, and the Michigan f.o.b. price with the New York f.o.b. price on a year-to-year basis. Overall, about 66 percent of the coefficients for the first comparison were equal to one. In addition, there was little difference in this distribution among time periods—64 percent in the first period, 67 percent in the second, and 52 percent in the third period. However, some difference in the distributions of the correlation coefficient among these periods existed. In the first period, 50 percent of the years had a coefficient less than 0.85. Comparable percentages for the second and third periods were 33 and 67 respectively.

For the comparison of the two f.o.b. prices, differences were observed. Over the entire time period, 50 percent of the years had a regression slope equal to 1.00. Within periods, 50 percent in the first period were equal to 1.00, 67 percent in the second period, and only 33 percent in the third. The pattern for the correlation coefficient was different: Only 10 percent of the years had a coefficient less than 0.85 in the first period, 22 percent in the second period, and 44 percent in the third.

A final question considered was whether a lag existed in the information flow between the Chicago wholesale market and the Michigan f.o.b. shipping points. The results of this analysis were not significant.

Overall, the results are mixed and do not lend themselves to general and defensible conclusions. With the data for all years pooled, the results suggested a tendency toward deviation of price performance away from the competitive norm. However, results obtained from a less aggregative degree of pooling indicated that this may be more a reflection of the pooling process itself than an indication of price performance. When considering either the estimates based on groups of years or the annual estimates, it is apparent that variation in price performance has occurred over time. Although there are marked exceptions, the results using groups of years show a better performance record during the period of futures trading. However, the noted exceptions are sufficient to preclude a high degree of confidence in this observation.

The Michigan f.o.b.—Chicago wholesale price comparisons are of particular interest in this study because of the special relation of these two to the futures market. Using the annual results as a reference point, the price performance relative to the competitive norm for this particular segment of the market may be acceptable—the expected regression coefficient of 1.00 was observed for 2 out of 3 years overall. However, the frequency of observing this value varies among the three time periods: The two-out-of-three ratio held approximately for the periods prior to and during futures trading but it dropped to one-out-of-two for the period following futures trading. In addition, the correlation coefficient was persistently lower in this latter period. As a minimum it seems clear that the nature of price performance over space has been changing but it is not at all clear what effect, if any, the presence or absence of the futures market has on this performance.

Futures Trading and Cash Prices

Whether the conclusions of this study come as a surprise depends, obviously, on the views one holds concerning the effect of futures trading on cash prices.

Some proponents of futures markets have argued that futures markets improve market efficiency, in some sense, and that, consequently, they result in less price variation. Some opponents have argued with equal fervor that futures trading introduces unnecessary and unwarranted price variation. Unfortunately, neither argument has been based on rigorous theoretical reasoning substantiated by compelling empirical evidence. In any event, neither position will find much support from this report.

An alternative position is to view a commodity price observed at a given point in time as a manifestation of existing and anticipated supply and demand conditions in the market. If this is true, then the introduction or removal of futures trading in the commodity will not necessarily exert a perceptible impact on price performance in the cash market.[13] However, if a futures market improves the quantity and quality of available market information; if it permits a reduction in transaction costs; if it provides for the transference of risk to those willing to carry it, hence reducing the total costs of marketing; if it facilitates the response to changes in existing or anticipated market conditions, then the presence of a futures market, by altering the environment within which cash price is established, could alter performance in the cash market. Nevertheless, cash price would still emerge as a result of interacting market forces, not as a result of the act of futures trading.

It is equally probable that changes in other marketing institutions will have an impact on cash price performance. Alterations in the type, frequency of release, and dissemination of market information by various governmental and private agencies, improved communication and transportation systems, technological developments affecting storage costs, and changes in grading practices illustrate changes continually occurring in commodity markets that have implications for price performance.

[13] See Thomsen, F. L. and R. J. Foote, Agricultural Prices, McGraw-Hill, 2nd ed., 1952, chapter 9, especially pp. 161-164, for a comprehensive discussion of the question of cash price—futures price relationships.

Finally, a casual observation of commodity prices will reveal "jitters" and "twitters"[14] in price movements, both cash and futures. The presence of these price movements reflects the fact that most agricultural commodities must be produced and marketed in a situation characterized by lack of information, uncertainty, personal whims, and so on. Such price movements scarcely serve as a basis for indicting or vindicating futures trading.

It does not follow from the observations made in the previous paragraphs that a futures market cannot be an important adjunct to the cash marketing system. Quite the contrary, there is a substantial body of literature, written by both students and users of such markets, identifying the numerous ways by which producers and handlers of agricultural commodities can and do use a futures market as an integral part of their respective businesses. It is beyond the scope of this report to delve into this body of literature. Suffice it to say here that futures markets, by providing an opportunity to hedge and to forward price, and by serving as a temporary alternative market, offer firms, both farm and agribusiness, profit opportunities that would not otherwise be available to them.

[14] Terminology used in Thomsen and Foote, op. cit., p. 152.

CHAPTER 3. PRICE THEORY AS A GUIDE FOR EMPIRICAL ANALYSIS

This chapter presents a brief review of the theory relating to the formation of price in a perfectly competitive market and raises some theoretical and empirical issues involving the use of this theory as a guide for an empirical evaluation of price performance in the cash onion market. A major conclusion of this chapter is that currently accepted price theory provides little, if any, specific insight into how one should proceed: From a conceptual standpoint, the theory fails to distinguish between price determination and price discovery, important considerations in real-world markets; from an empirical standpoint, the theory fails to delineate quantitative measures which may be used to evaluate price performance in a particular market.[15]

In response to these failures of the theory, alternative performance measures are used in this study. For each, an attempt is made to provide a theoretical framework within which it may be interpreted. Unfortunately, the correspondence between performance measures that can be calculated and ideal performance measures is tenuous at best. Consequently, the procedures followed must necessarily seem ad hoc. However, even though no single measure may be particularly meaningful in itself, it is felt that all such measures taken as a group provide a solid basis for assessing price performance.

Where appropriate, reference is made to the specific section of the report dealing with a particular performance measure. This should assist the reader in maintaining a perspective on what is being attempted throughout the report.

THE PERFECT MARKET

Some Theoretical Issues

In the perfectly competitive market, price is determined by the intersection of the market supply and demand curves. This price is an equilibrium, or market clearing, price—it is that unique price which brings about an equality between the quantity demanders are willing to purchase and the quantity that suppliers are willing to make available, all else constant. This may be expressed mathematically by the following system of equations:

$$(1) \quad Q_t^D = f(P_t, X_{1t}, \ldots, X_{nt})$$

$$(2) \quad Q_t^S = g(P_t, Z_{1t}, \ldots, Z_{it})$$

$$(3) \quad Q_t^D = Q_t^S$$

where

Q_t^S = quantity demanded

Q_t^S = quantity supplied

Pt = market price

X_i = demand shifters

Z_i = supply shifters

Given the structural parameters of the functions embodied in f( ) and g( ) and given values of the X_i and the Z_i there is a unique price, P^e, that will clear the market. When shifts occur in the basic market conditions, as manifestations of changes in structural parameters and/or in the magnitude of the relevant variables, a new equilibrium price is implied to which the market will move immediately. This immediate move to the new equilibrium price results from the several assumptions underlying the model; in particular, the assumption of perfect knowledge which means, among other things, complete knowledge of past, current, and future conditions as well as knowledge of all the relevant structural parameters of the system, such as demand elasticity, supply elasticity, and so on. Given this, any change in the basics of the system will result in an instantaneous move to the new equilibrium price.

In considering the use of this model as a framework for evaluating the historical record of observed market prices, there is a fundamental theoretical issue to be recognized. In the theory of the perfectly competitive market, the market becomes a place in which known things (supply and demand

[15] The validity of this conclusion clearly depends on how one defines theory. This question, which has yet to be resolved by philosophers of science, will not detain us here. The reference point in the text is that body of material typically taught in college courses under the rubric of price theory. Certainly, if to this is added all that is known, on the basis of empirical research, about agricultural markets then a substantial body of theory exists. The position on the price theory noted above provides a healthy perspective for assessing the research being considered. Specifically, a great deal of subjectivity and personal judgment is involved.

conditions) achieve expression in a unique way (equilibrium prices and quantities traded). Now, if the market is viewed, as it is by most economists, as an institution which facilitates the determination of value (market price) and the process of exchange (ownership transfer), then it would appear that an inconsistency has arisen. Indeed, if everything (supply and demand conditions) were known, why then is it necessary to simultaneously posit an institutional setting such as a market—with everything known, price in particular would be known and, consequently, the determination of market price and the transfer of ownership could be effected effortlessly without resort to a market.

This apparent inconsistency emerges from the failure to distinguish between price determination and the process by which that price is determined, or discovered, in the real-world markets. Perhaps it would be more accurate to suggest that economists have been so enamored with the perfectly competitive market that they have failed to raise the relevant question concerning the process whereby price is actually determined in the marketplace. As Larson states it, "The way in which the market determines price is apparently thought to be of no interest or concern provided it is truly a competitive market."[16]

To pursue this point further would divert us too far from our immediate objective. It is sufficient here to draw, from the theoretical work that has been done on this problem, the conclusion that the theory as conventionally presented fails to account for the process of price determination, at least to the extent that it provides a clear framework for empirical analysis of market prices. The consequence of this is the recognition that the market really serves as the vehicle which facilitates the process of discovering the equilibrium price. As Larson puts it, "... it seems clear that in any real situation the market itself gropes for the price." Consequently, "... *the market (is) ... a place where things are found out*, not merely a place in which known things find expression."[17]

The line of reasoning being considered here has definite implications for the evaluation of the historical record of market price. Specifically, it requires one to view the observed record as a manifestation of two types of underlying forces—those associated with changes in market conditions which call for the establishment of a new equilibrium price (the notion of price determination) and those forces associated with the attempt to discover what that new equilibrium price should be (the notion of price discovery).

Perhaps the following illustrations will provide some substance to the rather abstract point under discussion. Consider the onion market in Chicago on a particular day in May. Armed with the concept of a supply of and demand for onions, one would expect to observe a unique equilibrium price which would clear the market. Quite the opposite is likely to be the actual case—before the market has been cleared some onions will have been sold at, say, 33¢ per sack, some at 34¢ per sack, and so on. Thus, instead of observing a single market-clearing price one is confronted with a constellation of prices.

Another example: The onion production-marketing complex in the United States is characterized by a relatively short harvest period during which the major portion of the crop moves into storage for subsequent sale. Following this harvest period, no additional quantity is available for sale until the next harvest period; supply is fixed. In the context of the theory sketched above, one can visualize a single price which would clear the market of this fixed quantity of onions. However, when we turn to the statistical data we find not a single price at which a particular onion crop is sold. Rather, we find that sales occurred at an array of prices during the selling period. Moreover, it is quite likely that the observed market prices will vary over a wide range of values.

In light of the above discussion, these illustrations suggest that while in theory there may exist a price which will clear the market, observation of real-world markets will actually reveal an array, or constellation, of prices involved in the market clearing process. In Larson's terminology, the market must "grope" for the price which clears the market, and it is this process which we associate with the notion of price discovery.

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[16] Larson, A. B., "Studies of Mechanics of Pricing vs. Studies of Underlying Price-Making Forces," *Pricing As A Problem For Marketing Research*, Proc. Mktg. Res. Com., Western Agr. Econ. Res. Council, Univ. Calif., Berkeley, June 1963, Report No. 5, p. 13. The interested reader is referred to this article, which serves as the basis of the discussion in the test, and the literature cited therein. For more on the problem of price adjustment in a perfectly competitive market see Arrow, K. J. "Toward a Theory of Price Adjustment," *The Allocation of Economic Resources,* Abramovitz and others, Stanford Univ. Press, Calif., 1959, and the literature cited.

[17] Ibid. p. 15.

This discrepancy between expectations based on theory (a single market-clearing price) and observation of actual markets (a constellation of prices) is due to at least two characteristics of real-world markets which are not in accord with the specifications underlying the perfectly competitive market of theory. The first of these relates to the assumption that market participants possess perfect knowledge. Specifically, it is assumed that all persons in the market know the parameters of the supply and demand functions as well as the precise values of the relevant variables. In the theory, this assumption is utilized to assure that price will move immediately to the new equilibrium point in response to changes in market conditions. However, in the real world it is highly unlikely that such a state of knowledge will exist. Certainly the extent to which market participants can know the parameters of the demand function, for example, is open to question, as well as is their ability to perceive changes in these parameters.[18] A similar concern may be raised with regard to the parameters of the supply function.

In addition, given the difficulties of measurement one must seriously question the degree to which market participants can know the values of all of the relevant variables. For example, it is difficult to accept the assumption that traders in the Chicago wholesale onion market on a particular day know exactly the quantity of onions to be sold on that day, to say nothing of the quantities and prices existing simultaneously in other wholesale markets around the country. Without belaboring the point, it seems highly untenable to argue that traders in the Chicago wholesale onion market possess the requisite information to move directly to the market-clearing price associated with given market conditions.

The second problem encountered in the transition from the market of theory to the market of the real world involves the definition of the time-unit of observation. The market supply and demand functions of theory are assumed to hold "per unit of time"; real-world markets must operate on clock time, in the sense that a market may be defined in terms of a day, a week, a month, and so on. The difficulty for empirical analysis is that the basic theory provides no guidance concerning the selection of the appropriate time-unit of observation.[19] This may be of singular importance in evaluating the performance of a market, to the extent that conclusions drawn concerning the market's performance are sensitive to the specific time-unit of observation used in the particular analysis. Given a set of market performance criteria, it would not necessarily be inconsistent to conclude that a market performs unsatisfactorily when observing it on a day-to-day basis while its performance on a year-to-year basis is deemed satisfactory.

Of course, if the conclusion of market theory that an observed price represents the intersection of the market supply and demand curves is accepted then the implied definition of clock time is the length of time for that particular sale to take place. Further, changes in observed prices are to be interpreted as manifestations of changes in the basic market forces. However, to define clock time over such a small interval seems to rob the theoretical construct of some of its usefulness as a vehicle for abstracting from the minute complexities of reality in order to obtain basic insights into how that reality operates. Also, such a short time-unit of observation would be difficult to express quantitatively in terms of clock-time.

Finally, in light of the above discussion concerning the state of knowledge it seems unlikely that, even if market forces were to change so rapidly, market participants would perceive these changes and react to them with equal speed.

To this point, it has been argued that because market participants do not possess perfect knowledge and because clock time is a factor to recognize in real-world markets, the perfect market of theory leaves something to be desired as a framework for the analysis of observed prices. In particular, it seems clear that the historical record of market price should be viewed as a reflection of two types of underlying movements—those associated with changes in equilibrium conditions which call for the establishment of a new equilibrium price, and those associated with the attempt to discover what that new equilibrium price should be. The former case is associated with the notion of price determination; the latter with price discovery. On this argument, an evaluation of price performance would involve two considerations simultaneously: The response of market price to changing conditions, and the

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[18] Witness the large number of demand studies that have been conducted on agricultural commodities. See, for example, *A Handbook on the Elasticity of Demand for Agricultural Products in the United States,* Western Extension Marketing Committee Publication No. 4, July 1967, which summarizes from 115 research studies estimates of price and income elasticities.

[19] Chapter 1 presents a brief discussion of various time-units of observation and suggests the types of economic forces generally associated with each.

difficulty involved in discovering and responding to these changes.

Some Empirical Issues

Recognition of the distinction between the concepts of price determination and price discovery raises the fundamental question of how to identify and measure empirically the separate effects of these forces. Ideally, one should have criteria which would permit the precise separation of the observed price change into these two components. Unfortunately, there are no clearcut guidelines to follow, so it is necessary to resort to some ad hoc procedure that will, as a minimum, provide some insights into the problem. The following line of reasoning is employed in this report.

Price Variation Over Time. As a rule, by the end of the storage season the entire late summer onion crop has been sold. Consequently, the season's average price may be used as a beginning point since, in light of the previous discussion, it turns out to be the price which clears the market–it may be viewed as an empirical manifestation of the equilibrium price defined in the context of the perfectly competitive market. However, considerable variation about this average price will occur during the season. This observed variation reflects two underlying forces: The seasonal pattern of prices associated with a storage commodity where market forces attempt to allocate storage supplies over time, and the process of price discovery described above. In an attempt to examine this within-season variation, two not completely independent measures will be considered.

For a price series, such as weekly onion prices for a given crop year, the extent of the variation of individual (weekly) prices about the average price for the season may be measured by a statistic called the coefficient of variation. Heuristically, this is a number which measures the variation in actual weekly prices as a percentage of the average price for the season. Since it is expressed in percentage terms, it has the advantage of permitting direct comparison of variation from year to year for a particular price series, such as the Michigan f.o.b. shipping point price, to see whether the degree of variation has been changing over time; and it permits direct comparison of the variation in two different price series, such as the Michigan and New York f.o.b. price series. This, of course, is an aggregate measure and does not distinguish between variation associated with the expected seasonal pattern of onion prices and the variation associated with price discovery.

Chapter 4 is concerned with year-to-year price variation and with the aggregate measure of within-season price variation. An attempt is made to provide a criterion, or reference point, for evaluating the coefficient of variation, as a measure of within-season price variation, calculated for the Michigan f.o.b. shipping point price series for each crop year during 1930-67. The procedure is to use a model of the perfectly competitive market in time to generate a seasonal price pattern for a storage crop such as onions. On the basis of this model, it is possible to predict the coefficient of variation of seasonal prices for a particular crop year. This predicted value may then be used as a reference point for evaluating the actual coefficient of variation for that crop year.

In principle, this comparison of the predicted with the actual coefficient of variation provides a measure of the extent to which the real-world onion market operated under competitive conditions. However, in this phase of the study, considerable caution should be exercised in interpreting these comparisons since further theoretical and empirical work is needed to provide a solid basis for evaluating the performance of the onion market. Nevertheless, it is felt that these comparisons do provide meaningful insights concerning the performance of the onion market with respect to the competitive norm. In particular, they highlight the extent to which performance may have been changing relative to the competitive norm over time.

In an attempt to disaggregate this measure of within-season price variation (the coefficient of variation), two analyses are carried out. One focuses on the expected seasonal pattern of price. This traditional analysis of seasonal price patterns is presented in chapter 5.

The second measure of within-season variation is the monthly price range which is used as a crude measure of price variation associated with the process of price discovery. This analysis is presented in chapter 6. There are no strong and compelling a priori reasons for defending the use of the monthly price range as a measure of price discovery. However, in the spirit of approximation, it could be argued that for a particular period within the marketing season, say a month, there exists a unique equilibrium price such that, if it were known by all the traders in the market, then all of the trading for that time period would be conducted at that one price. To the extent that the market participants do not possess the requisite information to move directly to this price, then it must be discovered through the trading process. Consequently, observed price variation during this period should provide an empirical measure of the underlying price discovery process. While there are no criteria for evaluating the observed price range for a particular month, it is possible to compare changes in observed price ranges among months and over time and, consequently, to draw tentative conclusions concerning the extent to which observed price variation due to the process of price discovery has been changing.

Price Variation Over Space. The theory of the perfectly competitive market, as outlined in the first section of this chapter, abstracts from the spatial dimension of the market. In real-world terms, it does not tell us where the market is located geographically—it implicitly assumes a market exists wherever buyers and sellers come together for purposes of trading. Further, it fails to recognize the real-world situation where a particular commodity is priced in markets separated by space. In the case of onions, for example, shipping-point markets exist in Michigan, New York State, and Texas. Similarly, wholesale markets for onions produced in these regions exist in most of the major cities in the country.

This spatial aspect of real-world markets is considered in chapters 8 and 9 by drawing upon the theory of the perfectly competitive market in space. From this theory, performances measures are developed and evaluated.

CHAPTER 4. YEAR-TO-YEAR AND WITHIN-YEAR PRICE VARIATION

This chapter is the first of four concerned with the variation in cash onion prices through time. Two basic types of price variation are considered: Changes in the level of prices from year to year as measured by average prices for each year, and deviation of actual prices around these averages within the year. The current chapter considers only an aggregate measure of within-season price variation. Seasonal and within-month price variability is examined in detail in chapters 5 and 6.

YEAR-TO-YEAR PRICE VARIATION

Variation in the average level of onion prices is discussed in this section for the crop years from 1930 to 1967 for different points in the marketing system and at different levels of aggregation over time. The major part of the discussion centers on three price series—Michigan and New York f.o.b. shipping point and Michigan wholesale at Chicago—on a year-to-year basis. A final subsection compares average prices at seven marketing points for three periods.

The season's average prices for late summer onions for three selected marketing points are shown by crop year in table 1 and figure 1. Although considerable year-to-year variation is exhibited, all three price series have moved in close conformity over time, as would be expected since all three market points are integral parts of the overall national market within which onions are priced. However, a careful examination of table 1 and figure 1 reveals that there is considerable difference in the level and distribution of prices among these three series. These among-series relations are more easily examined by the use of frequency distributions which show the percentage of actual prices falling within stated price intervals.

The frequency distributions for each of the three price series are shown in table 2 and figure 2. The modal group[20] for the Michigan f.o.b. price was \$0.76-\$1, which includes 32 percent of the annual average prices. Fifty percent of the annual prices fell in the \$0.26-\$0.75 range and 18 percent of observed prices exceeded \$1 per 50-pound sack. Approximately 33 percent of the wholesale prices for Michigan onions in Chicago fell in the \$0.51-\$0.75 range and almost 30 percent exceeded \$1 per 50-pound sack. The modal group for the New York f.o.b. shipping point price was the group over \$1, which includes almost 33 percent of the annual average prices. The remaining prices were about equally distributed among the other three categories.

The underlying distribution of annual prices appeared to be somewhat different for the three price series. The Michigan f.o.b. price distribution may be characterized as skewed, with a tendency for low prices to occur with a higher frequency. On the other hand, the distribution of the Michigan wholesale price at Chicago is bimodal, with approximately equal frequencies occurring for the \$0.51-\$0.75 and the over \$1 groups. The New York f.o.b. distribution is approximately rectangular,[21] although there is a tendency for high prices (over \$1) to occur with a greater frequency.

Figure 1 clearly evidences rather extreme year-to-year variation in onion prices, a price pattern suggestive of the cobweb phenomenon felt to exist for many seasonally produced agricultural commodities. The presence of this phenomenon frequently makes it difficult to determine whether or not an underlying trend is present. This appears to be particularly true for the prices being considered here. Consequently, the following two sections are concerned with the trend and with the cobweb pattern in onion prices respectively. Only the Michigan f.o.b. price is considered since the long-run patterns of the other two price series are similar.

Trend in Michigan f.o.b. Price

One method of eliminating annual variation from a price series to detect underlying trends is to use a moving average of the actual prices. It is seldom clear what time interval to use so both a 2-year and a 3-year moving average have been calculated for the Michigan f.o.b. price. These are presented in figure 3. For some time intervals, the 2-year calculation seems to do better smoothing job while the 3-year calculation seems better for other periods. In either case, the same general underlying trend is revealed by both procedures.

In general, onion prices declined from 1930 to the mid-1950's. The rate of decline was quite precipitous

[20]The modal group is that group containing the largest number of actual prices.

[21] A rectangular distribution has an equal number of observations in each group.

Table 1.–Late summer onions: Season's average price, selected marketing points, crop years 1930-67[1]

Crop year	Michigan, f.o.b. shipping point	Michigan, Chicago wholesale	New York, f.o.b. shipping point
	Dollars per 50-pound sack		
1930	0.40	0.44	0.46
1931	2.69	2.36	2.65
1932	.62	.62	no data
1933	1.15	1.15	1.14
1934	1.13	1.16	1.14
1935	.80	.72	.87
1936	.49	.48	.52
1937	1.04	.87	1.03
1938	.90	.87	.93
1939	.82	.79	.86
1940	.64	.74	.82
1941	1.21	no data	1.33
1942	.82	no data	.92
1943	.94	1.22	.98
1944	.61	.67	.69
1945	.96	1.17	1.06
1946	.34	.40	.40
1947	1.21	1.54	1.28
1948	.43	.50	.47
1949	.78	.71	.92
1950	.36	.35	.44
1951	.78	.79	.87
1952	1.06	1.04	1.15
1953	.28	.34	.30
1954	.54	.58	.56
1955	.63	.63	.66
1956	.48	.55	.52
1957	.59	.71	.75
1958	.96	1.03	1.17
1959	.44	.57	.48
1960	.46	.60	.49
1961	.97	1.08	1.03
1962	.53	.62	.55
1963	.66	.78	.64
1964	.62	.78	.70
1965	.47	.50	.46
1966	.98	1.08	1.05
1967	.90	1.00	1.06

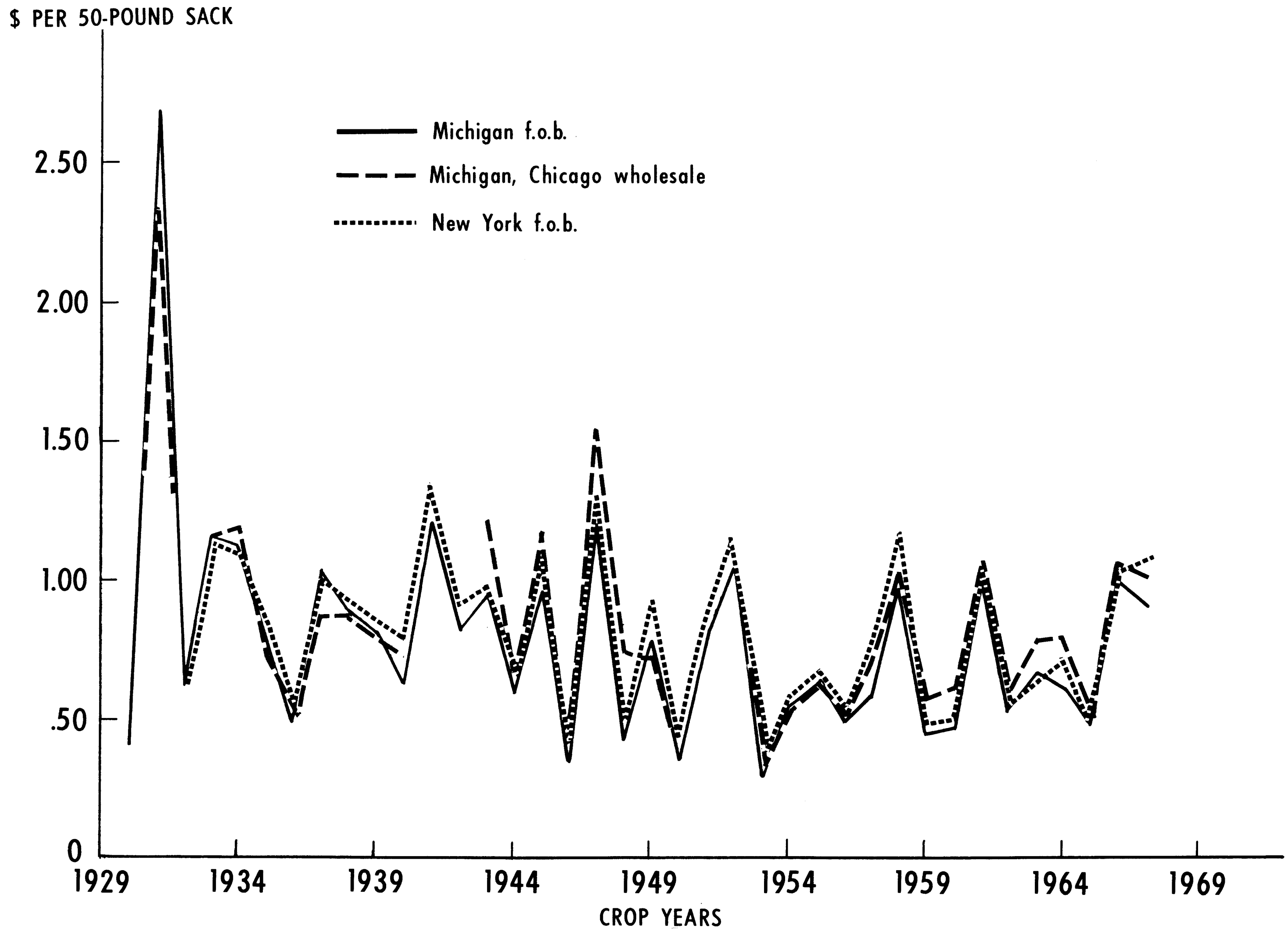
[1] Prices deflated by Index of Prices Received by Farmers, All Commodities, 1910-14 = 100.

from 1931 to 1936, dropping about $1 per sack. Following the low in 1936, price fluctuated rather steadily between $0.75 and $1 until 1945 when the downward trend was resumed. This decline persisted until 1954, with the obvious exception during the early 1950's. Prices appeared to bottom out during the mid-1950's and since that time there appears to have been a rather persistent upward trend. Over all, the period from 1930 to 1967 may be characterized as one of declining prices from 1930 to the mid-1950's and one of stable to slightly rising prices since that time.

The Cobweb Character of Onion Prices

As mentioned above, many annually produced agricultural crops exhibit a characteristic referred to as a cobweb pattern, where high prices are followed by low prices and low prices are followed by high prices. A simplistic explanation is that when producers experience a high price from the sale of a crop they plant heavy for the next crop under the expectation of a continuation of the high price. However, the large crop, in turn, results in a low price and producers cut

SEASON'S AVERAGE PRICE OF LATE SUMMER ONIONS



PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910-14 = 100.

Figure 1

Table 2.—Frequency distribution, annual average onion price, selected marketing points, 1930-67

Annual average price per 50-lb. sack	Michigan, f.o.b. shipping point	Michigan, Chicago wholesale	New York, f.o.b. shipping point
		Percent	
0-$0.25	0	0	0
$0.26-$0.50	.263	.194	.216
$0.51-$0.75	.237	.333	.243
$0.76-$1.00	.316	.194	.216
Over $1.00	.184	.279	.325

back on plantings the following year. Thus, a sawtooth, or cobweb, pattern of prices emerges.

The pattern of price shown in figure 1 strongly suggests that such a phenomenon is present in onion prices. This is examined in figure 4, where the difference in price from one year to the next is plotted for the Michigan f.o.b. price series. For a perfect cobweb, price change would alternate in sign from plus to minus from year to year. The cobweb phenomenon in onion prices is clearly apparent, with the change in price from one season to the next tending to approximate the expected alternation from a plus to a minus sign. For the entire period, there were 28 years where the season's average price changed in the opposite direction from the previous year's change. For the remaining 9 years, the price change continued the pattern established by the previous year's price change. However, there were only two periods, 1935-36 and 1939-40, when the previous change was continued for more than 1 year.

During 1930-40, the cobweb pattern was exhibited in only 5 years. On the other hand, during both 1949-57 and 1959-67 the cobweb pattern occurred in 7 in the 9 years. The reason for this tendency to follow the cobweb pattern more closely during the latter two periods is not clear. As a beginning point, it could be argued that the cobweb effect might tend to dissipate over time as farmers learn what happens when they respond to the expectation of a continuance of the previous year's price. In addition, to the extent that increased specialization in production and marketing practices restricts the range of alternatives available to farmers this line of reasoning would be reinforced. It appears that such has not been the case for onions. However, it should be noted that the period during which prices tended to diverge from the cobweb pattern was also the period during which price exhibited a strong downward trend, while for the latter two periods the price level remained relatively constant.

Prices: All Marketing Points—
Selected Time Periods

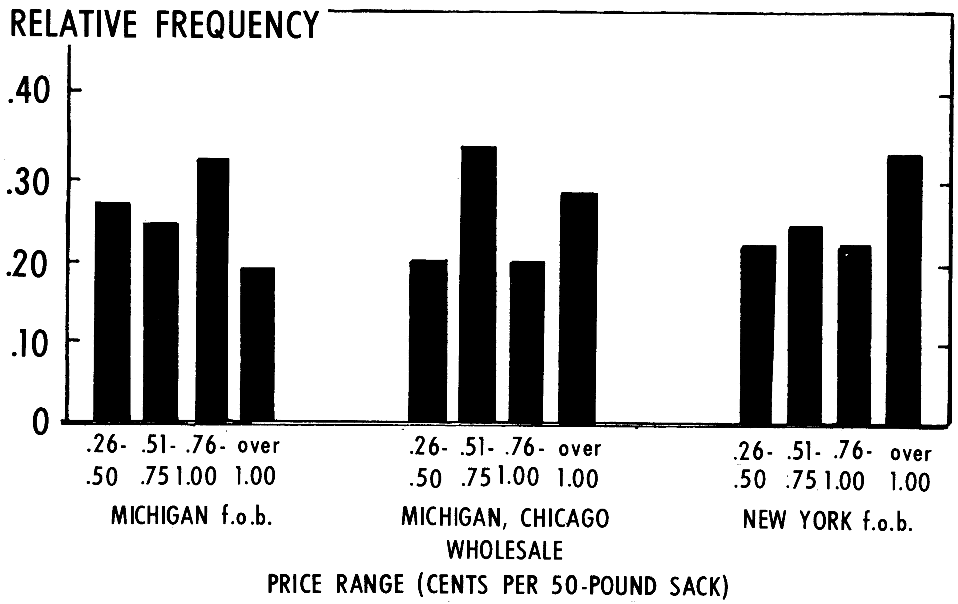
The season's average prices for seven marketing points for selected time periods are presented in table 3. The same general patterns and relationships exhibited by earlier tables and graphs are reflected here. The 1930-40 period was one of the highest prices. For all marketing points, prices during 1959-67 averaged higher than during 1949-57, but only slightly so. As would be expected, the wholesale prices for onions produced in a particular region were higher than the prices at the respective f.o.b. shipping point. The one exception to this occurred in 1930-40 when the Michigan f.o.b. price averaged slightly higher than the wholesale price for Michigan-grown onions in Chicago.

WITHIN-SEASON PRICE VARIATION

The coefficient of variation is used in this section as an aggregate measure of within-season price variation in a descriptive way—variability associated with price determination and with price discovery is subjects for subsequent chapters. There are no obvious criteria to use as a reference point for interpreting an observed coefficient of variation in the context of price performance. Specifically, one might like to be able to assert that a particular coefficient is too large or too small relative to some norm. An attempt to provide such a reference point is presented in a later section.

The coefficients of variation for three selected price series are shown in table 4 and figure 5 by crop years. Although there has been considerable year-to-year variation in the magnitude of the coefficient of variation, it does tend to exhibit a slight downward trend since 1930. However, this extreme year-to-year variation may make this generalization somewhat

FREQUENCY DISTRIBUTION OF ANNUAL AVERAGE ONION PRICES, 1930-67



PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910-14=

Figure 2

meaningless. In any event, each successive peak value has been lower than the previous one while the successive extreme lows have been of the same order of magnitude. The one major exception to the overall picture occurred during World War II when the coefficient of variation was extremely low. However, this may simply reflect the abnormal situation brought about by a war economy and is, consequently, of little interest in the overall evaluation of the price performance of the onion market.

The frequency distribution of the coefficient of variation for each of the three price series is shown in table 5. In general, price at shipping point varied more within the series than the price at wholesale. For the Michigan f.o.b. price, the coefficient of variation exceeded 31.0 with a frequency of 34 percent and the New York exceeded this value with a frequency of 40.0 percent. For the Michigan wholesale price in Chicago, this level of within-season variation occurred with a frequency of only 20 percent. This relationship between the extent of price variation between f.o.b. and wholesale is as would be expected since demand at the shipping level is derived from the demand at wholesale. For a perfectly competitive market in space,[22] absolute changes in price would be the same at f.o.b. shipping point as at wholesale; since the f.o.b. price tends to be lower,[23] the result is a greater percentage change at f.o.b.

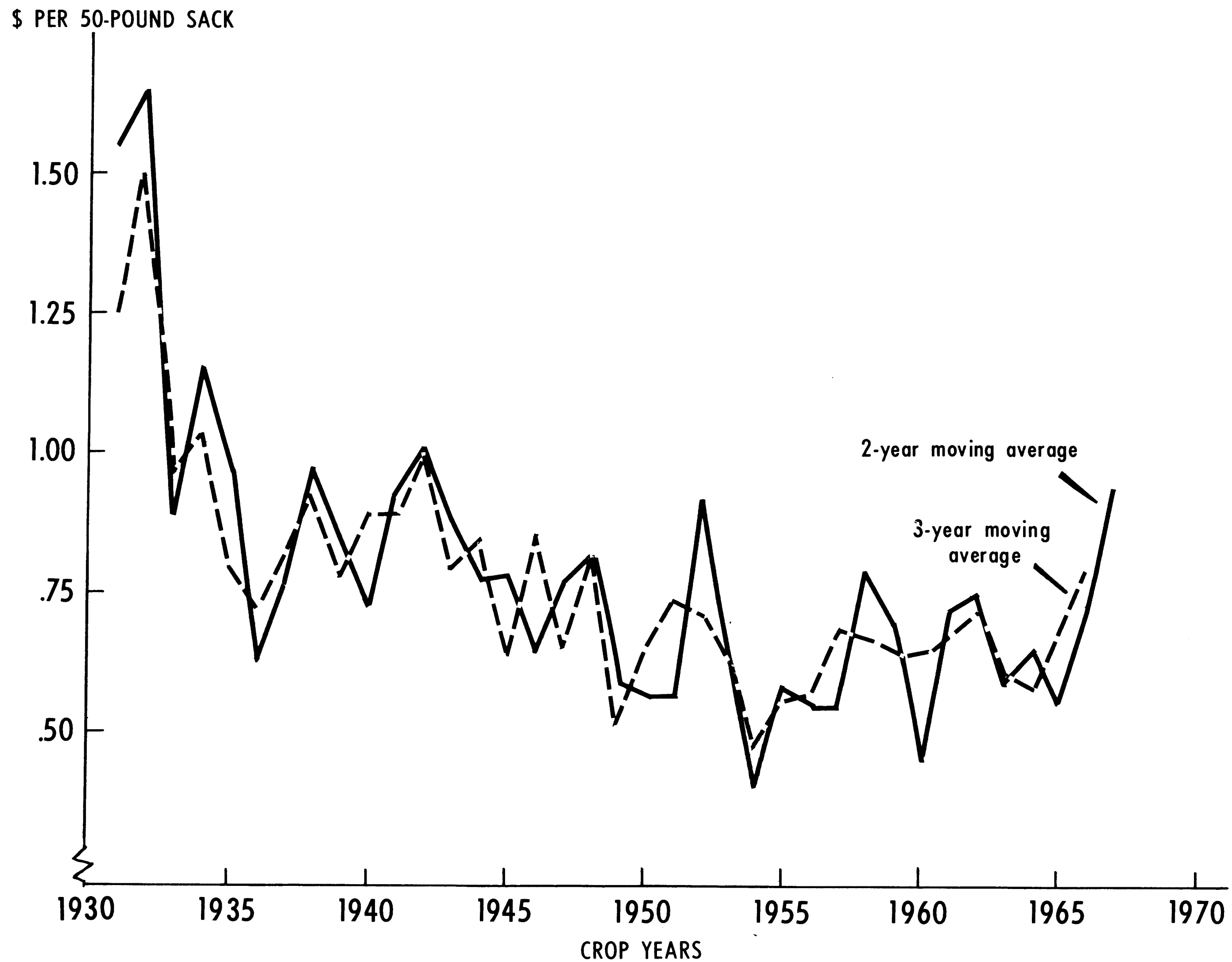
The coefficients of variation corresponding to the average prices shown in table 3 are presented in table 6. In terms of among-market comparisons, the within-season price variation at shipping point is greater than at wholesale markets, as expected based on the above discussion. The one exception to this occurred for the Texas f.o.b. price and Texas wholesale price in New York for 1930-40. The Michigan and New York f.o.b. prices exhibited approximately the same degree of within-season price variation in each of the three periods. The within-season variation in the Texas f.o.b. price was substantially less, a reflection of a markedly shorter shipping reason.[24] The wholesale

[22] See chapter 8.

[23] See table 5.

[24] See Comparison of Theoretical and Actual Coefficients of Variation, this chapter, where the coefficient of variation is shown to be a function of the length of the shipping season.

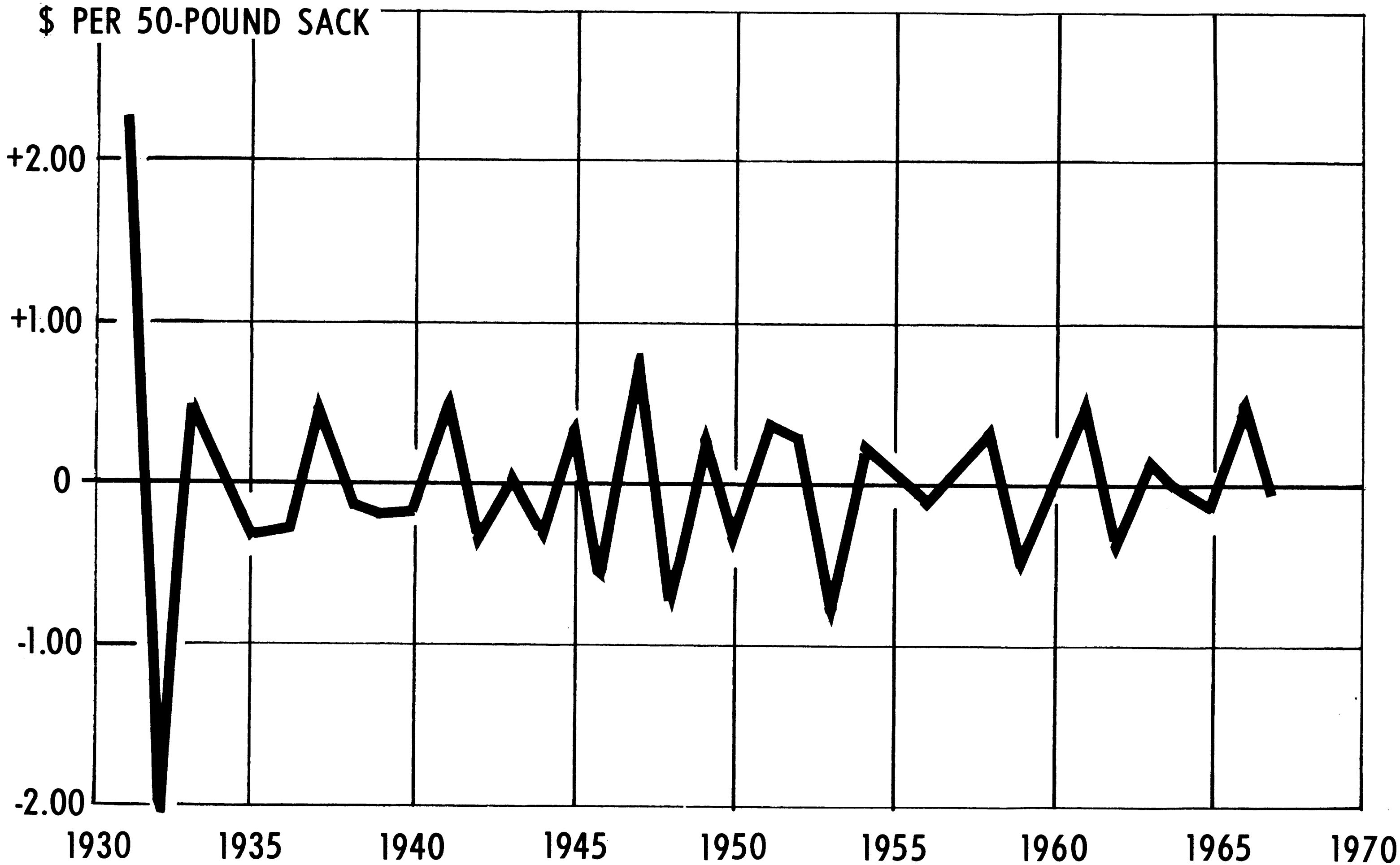
MICHIGAN f.o.b. CASH ONION PRICES



PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910 - 14 = 100.

Figure 3

YEAR-TO-YEAR CHANGE IN MICHIGAN f.o.b. SHIPPING POINT PRICE FOR ONIONS



PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910-14 = 100.

Figure 4

Table 3.—Late summer onions: Season's average price, selected marketing points, selected time periods, 1930-67[1]

Period	Marketing point[2]						
	MIFOB	MICWH	MINWH	NYFOB	NYNWH	TXFOB	TXNWH
	Dollars per 50-pound sack						
1930-40	0.97	0.93	1.27	1.04	1.16	1.29	1.82
1949-57	.61	.63	.81	.68	.76	.67	1.21
1959-67	.67	.78	.95	.72	.85	.89	1.34

[1] Prices deflated by Index of Prices Received by Farmers, All Commodities, 1910-14 = 100.

[2] The symbols used here and in subsequent tables are defined as follows:

MIFOB = Michigan f.o.b. shipping point
MICWH = Chicago wholesale price for onions produced in Michigan
MINWH = New York City wholesale price for onions produced in Michigan
NYFOB = New York f.o.b. shipping point
NYNWH = New York City wholesale price for onions produced in New York State
TXFOB = Texas f.o.b. shipping point
TXNWH = New York City wholesale price for onions produced in Texas.

prices in the two markets, Chicago and New York City, for onions shipped from the three different producing regions all tended to reflect about the same degree of within-season price variability.

Over time, a definite change in variation is evident. Except for the Texas f.o.b. price, within-season price variation has been decreasing. In addition, the general pattern was a substantial decrease between the first and second periods and a somewhat smaller decrease between the second and third periods.

As mentioned above, the absence of criteria for evaluating observed coefficients of variation precludes conclusions concerning price performance relative to some norm. The most that may be said on the basis of the data presented here is that within-season price variation showed a tendency to decline from 1930 to 1967. An attempt to say more is presented in a following section.

COMPARISON OF THEORETICAL AND ACTUAL COEFFICIENTS OF VARIATION

In this section, the perfectly competitive market in time is used as a reference point to evaluate observed variation in cash onion prices relative to the variation that would be expected if the onion market were operating under perfectly competitive conditions. Although the procedure employed is tenuous, perhaps even unacceptably naive, it is felt that sufficient insight into the price performance of the onion market is obtained to justify its consideration. Even though the comparison between the optimal and observed coefficients for a particular year may be of questionable significance, it does not necessarily follow that a consideration of changes over time in the relation between the optimal and observed coefficient is void of meaning.

The Setting

The production-marketing complex of the late summer onion crop is characterized by a harvest period of relatively short duration with the crop placed in storage for later sale. In such a setting, the role of market price becomes one of allocating the fixed storage stocks over time until new-crop supplies become available. Consequently, the notion of a seasonal price pattern is introduced, which means, among other things, that one would expect to observe within-season variation of price about the average price for the season. By drawing upon the perfectly competitive market in time, it is possible to describe what the optimum seasonal pattern of price should be. Given this, it becomes possible, in turn, to measure this within-season price variation using the coefficient of variation. The objective here is to derive the formula for computing this predicted, or optimal, coefficient of variation, and to compare it with the observed values given in the previous section.

Table 4.—Onions: Coefficient of variation of season's average price, selected marketing points, crop years 1930-67

Crop year	Michigan, f.o.b. shipping point	Michigan, Chicago wholesale	New York, f.o.b. shipping point
		Percent	
1930	14.1	16.2	13.5
1931	47.6	53.6	51.8
1932	38.6	18.4	no data
1933	21.1	21.4	21.3
1934	48.1	44.0	47.6
1935	19.9	18.1	15.7
1936	43.9	35.8	31.6
1937	22.0	20.6	22.2
1938	14.4	17.1	18.4
1939	51.3	20.3	52.5
1940	22.6	25.8	39.7
1941	25.7	no data	33.5
1942	15.3	no data	12.9
1943	6.3	6.7	12.1
1944	17.3	11.3	15.4
1945	8.7	14.3	10.6
1946	28.2	23.5	26.4
1947	38.3	27.4	35.1
1948	15.1	12.0	15.5
1949	41.6	49.2	30.6
1950	30.7	12.2	28.1
1951	38.2	38.3	36.0
1952	23.0	24.3	21.2
1953	18.0	18.7	12.0
1954	14.5	16.1	15.1
1955	25.2	32.3	21.4
1956	21.8	13.9	22.6
1957	30.6	23.6	41.4
1958	35.8	29.6	45.7
1959	15.3	15.1	10.5
1960	25.6	17.7	31.0
1961	39.0	34.4	36.0
1962	16.8	12.5	17.1
1963	10.6	7.7	14.7
1964	19.4	18.1	10.7
1965	36.6	15.3	31.8
1966	18.9	13.6	14.3
1967	33.5	21.6	39.3

The Optimal Coefficient of Variation

The model employed is presented in Bressler and King.[25] To make the current development self-contained, this theory will be presented here in outline form.

One-period production and multiperiod consumption are assumed. This permits storage for a limited time. In addition, the terminal storage period is assumed to occur prior to the harvesting of a subsequent crop and no new-crop supplies become available during the storage period. To facilitate subsequent computation, linear equations are used to obtain explicit solutions.

Let

(1) S = Quantity harvested and sold in subsequent periods; S is a constant for the storage-selling season.

[25] Bressler, R. G., Jr., and R. A. King, *Markets, Prices and Interregional Trade*, John Wiley and Sons, Inc., 1970, chapter 11.

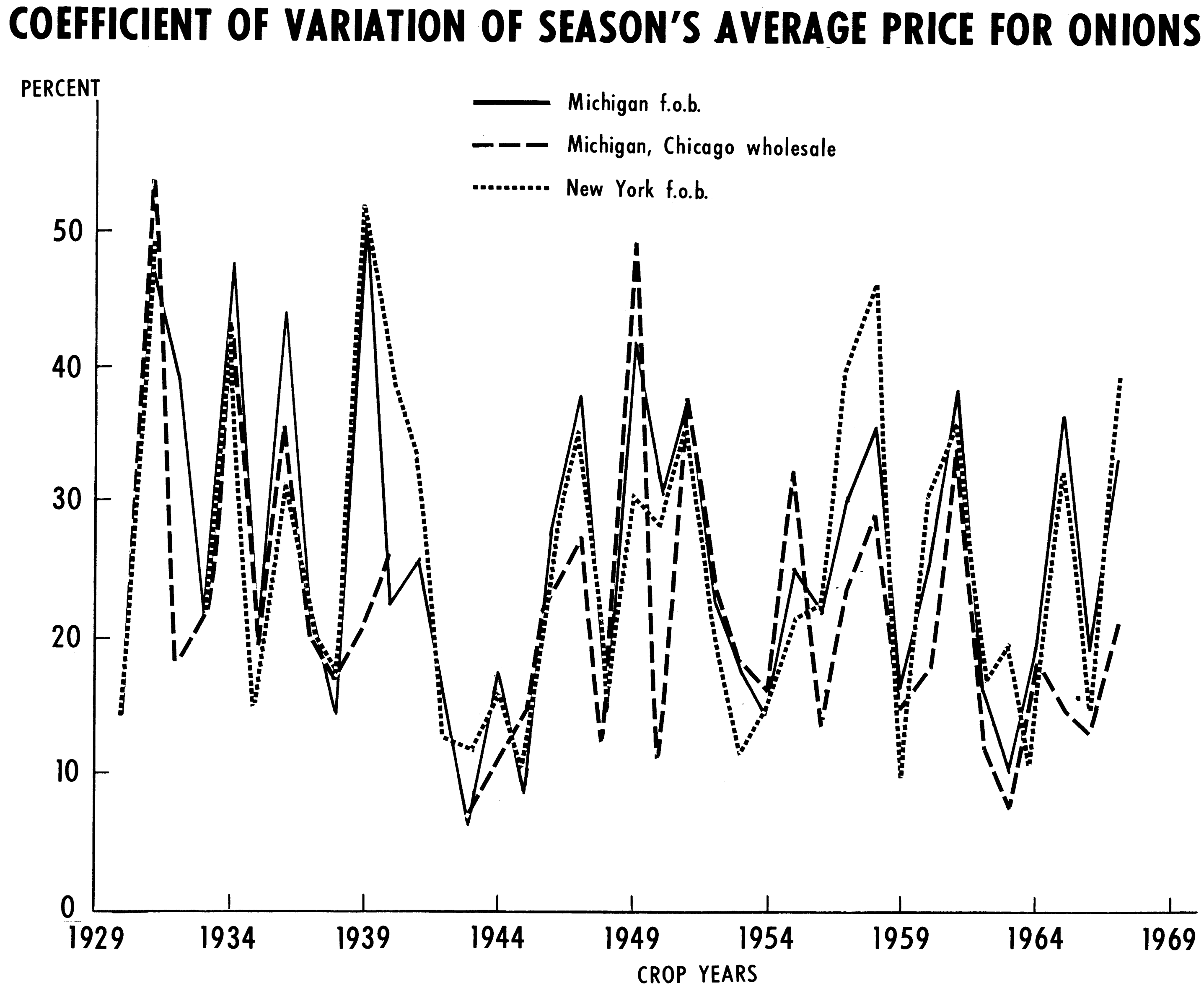

COEFFICIENT OF VARIATION OF SEASON'S AVERAGE PRICE FOR ONIONS
PERCENT
Michigan f.o.b.
Michigan, Chicago wholesale
New York f.o.b.
50
40
30
20
10
0
1929
1934
1939
1944
1949
1954
1959
1964
1969
CROP YEARS

Figure 5

Table 5.—Frequency distribution of the coefficient of variation, annual average onion price, selected marketing points, 1930-67

Coefficient of variation	Michigan, f.o.b. shipping point	Michigan, Chicago wholesale	New York, f.o.b. shipping point
		Percent	
0-20.0	39.5	55.5	40.6
21.0-30.0	26.3	25.0	18.9
31.0-40.0	21.1	11.1	27.0
41.0-50.0	10.5	5.6	8.1
Over 50.0	2.6	2.8	5.4

Table 6.—Coefficients of variation, late summer onion prices, selected marketing points, selected periods, 1930-67

Period	Marketing point[1]						
	MIFOB	MICWH	MINWH	NYFOB	NYNWH	TXFOB	TXNWH
1930-40	31.2	26.5	23.2	31.4	27.4	21.5	23.4
1949-57	27.1	25.4	19.5	25.4	22.2	25.6	16.5
1959-67	24.0	17.3	14.4	22.8	21.0	22.6	15.4

[1] See table 3.

The demand curve for each time period, t, is given by

(2) $D_t = a - bP_t$, $t = 1, \ldots, n$, where n is the terminal storage selling period.

Storage cost is given by

(3) $C_t = (t - 1)e$, where e is the cost per unit stored per time period.

It would be more realistic to include a constant term in (3) to reflect the fact that there are fixed costs involved as the commodity moves into and out of storage. However, since the only effect of fixed costs on intraseasonal price relations is to alter the price change between period 1 and period 2 by a constant amount, it was decided to ignore it, to keep the analysis as simple as possible.

As a consequence of assuming a perfectly competitive market in time, the price equation is:

(4) $P_t = P_1 + (t-1)e$

which shows that the price in the t-th period is equal to the initial period price plus the cost of storage to the t-th period, i.e., price should rise seasonally by the cost of storage.

By introducing the equilibrium condition that the sum over sales in the *n* selling periods is equal to the stocks available at the beginning of the season, it is possible to express P_t in terms of the parameters of the demand function and the total quantity of stocks. However, this will not be done since interest here is on deriving the coefficient of variation for the seasonal price pattern.

The variance of price within the season is given by:

$$(5) \quad V(P) = \frac{1}{n} \sum_{t=1}^{n} (P_t - \bar{P})^2$$

which may be calculated by the following:

$$(6) \quad V(P) = \frac{1}{n} \sum_{t=1}^{n} P_t^2 - \bar{P}^2$$

The mean, or average, price, $\bar{P}$, may be calculated by summing equation (4) over the *n* selling periods and dividing by n. This yields:

$$(7)\quad \bar{P} = \frac{1}{n}\sum_{t=1}^{n}[P_1 + (t-1)e] = P_1 + \frac{(n-1)}{2}e$$

The calculation of $\frac{1}{n}\sum_{t=1}^{n} P_t^2$ is somewhat more complicated since it requires first squaring equation (4) for each value of t, summing over all n values and dividing this total by n. By straightforward calculation, the sum over all the values squared is given by:

$$(8)\quad \sum_{t=1}^{n} P_t^2 = nP_1^2 + n(n-1)P_1 e + (1 + 2^2 + 3^2 + \ldots + (n-1)^2)e^2$$

since:

$$(9)\quad (1 + 2^2 + 3^2 + \ldots + (n-1)^2) = \frac{n(n-1)(2n-1)}{6}$$

we have:

$$(10)\quad \frac{1}{n}\sum_{t=1}^{n} P_t^2 = P_1^2 + (n-1)P_1 e + \frac{(n-1)(2n-1)}{6}e^2$$

Consequently,

$$(11)\quad V(P) = \frac{1}{n}\sum_{t=1}^{n} P_t^2 - \bar{P}^2 = \left[\frac{(n-1)(2n-1)}{6} - \frac{(n-1)^2}{4}\right]e^2 = \frac{(n^2-1)e^2}{12}$$

Finally, the coefficient of variation is given by:

$$(12)\quad CV(P) = \frac{S(P)}{\bar{P}} = \frac{e\sqrt{\frac{(n^2-1)}{12}}}{P_1 + \frac{(n-1)e}{2}}$$

Equation (12) shows the coefficient of variation to be a function of the number of selling periods during the storage season, the cost of storage per unit per time period, and the price in the initial selling period—a result which seems reasonable. Using this formula it is possible for any given season to determine what the coefficient of variation—the degree of within-season variation of price about the season's average price—should be if the market operated under conditions of perfect competition in time.

COMPARISON OF ACTUAL AND OPTIMAL COEFFICIENTS

In this section, the observed coefficients of variation for the Michigan f.o.b. price series are compared with the optimal, or predicted, coefficients calculated using equation (12) developed above. As shown there, the optimal coefficient of variation is a function of the price during the first selling period of the season and the cost of storing one unit of the commodity for one period. Thus, to compute the optimal coefficients it is necessary to have information concerning the cost of storing onions.

Since weekly prices are used in this analysis, the desired information would be the cost per unit per week. Unfortunately such information is not readily available. A brief review of the literature supplemented with discussions with an extension marketing specialist at the University of Wisconsin suggested that a figure in the range of 5 to 10 cents per sack per month would be a reasonable approximation.

It must be emphasized that this is, at best, a crude approximation since storage costs will vary depending on type of storage, time of harvest, length of storage season, and so on. In addition, it seems reasonable to assume that storage costs have been changing over time so that costs applicable for the mid-1930's would not be relevant for the late 1960's. However, since the comparison undertaken here is meant to be suggestive rather than definitive it was felt that this crude approximation was acceptable for the purpose at hand. Consequently, optimal coefficients were calculated for two levels of storage cost,

RATIO OF ACTUAL TO PREDICTED COEFFICIENT OF VARIATION, MICHIGAN f.o.b. CASH ONION PRICES

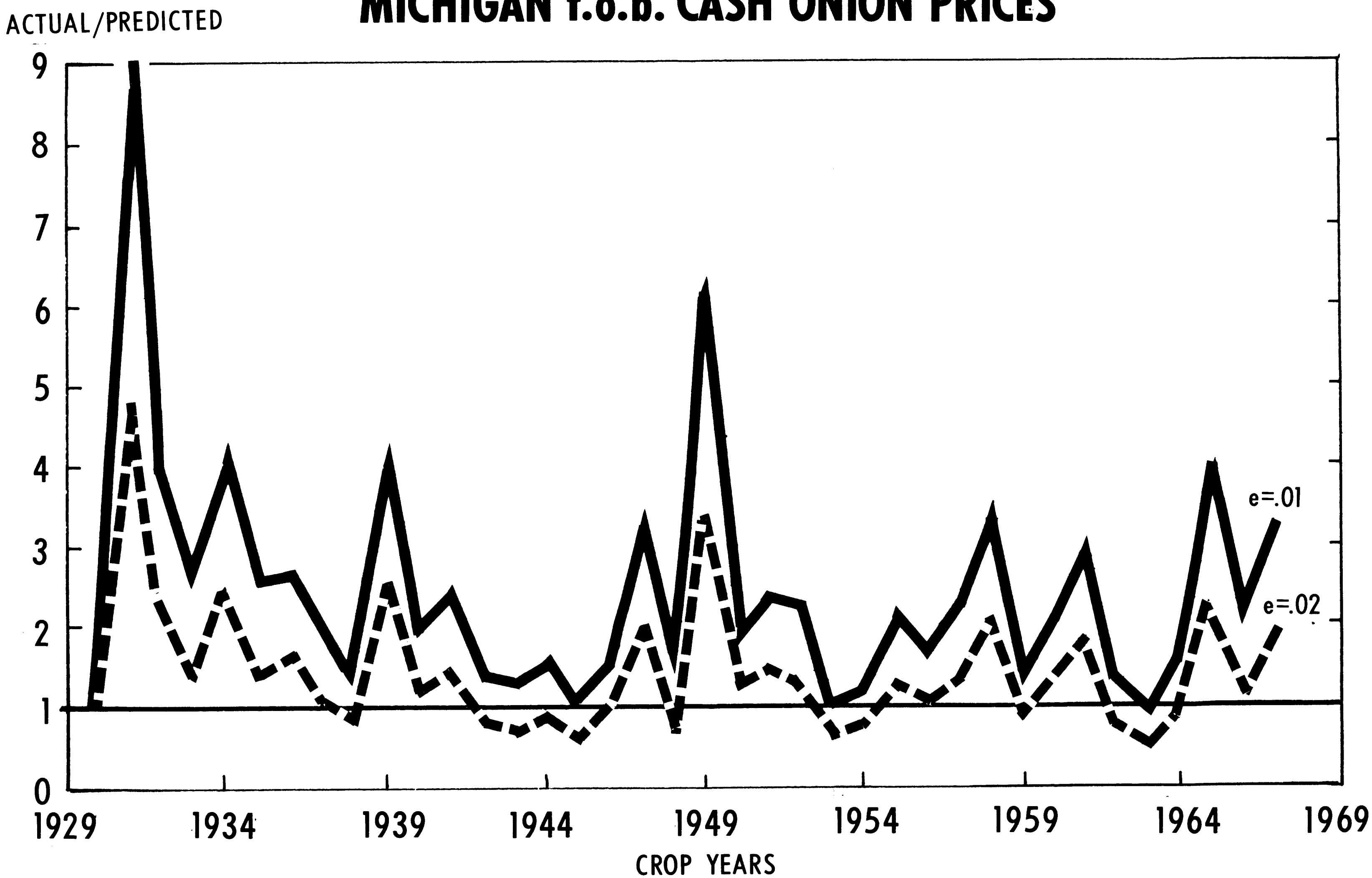


Figure 6

Table 7.—Onion prices: Frequency distribution of ratios of actual coefficient of variation to predicted coefficient of variation under alternative storage costs, 1930-67 and selected periods

Ratio	Storage cost							
	1 cent per 50-pound sack				2 cents per 50-pound sack			
	1930-40	1949-57	1959-67	1930-67	1930-40	1949-57	1959-67	1930-67
Less than 0.3	0	0	0	0	0	0	0	0
0.3-0.7	0	0	0	0	.091	.222	.111	.184
0.8-1.2	.091	.222	.111	.131	.273	.222	.555	.342
1.3-1.7	.091	.111	.333	.264	.273	.444	0	.211
1.8-2.0	.182	.111	.222	.131	0	0	.222	.079
Over 2.0	.636	.556	.333	.474	.363	.111	.111	.184
Simple average ratio	3.6	2.3	2.2	2.5	1.9	1.4	1.3	1.4

1 cent per sack per week and 2 cents per sack per week. Since the focus of the comparison is on relative rather than absolute values the same qualitative conclusions can be drawn independent of the actual level of storage costs.

To facilitate comparisons, the measure used is the ratio of the actual coefficient of variation to the optimal coefficient for a particular year. Thus, a ratio of 1.0 means that the actual was equal to the optimal, 1.5 would mean that the actual variation exceeded the optimal by 50 percent, and a ratio of 2 would mean that actual variation was twice as large as the optimal. In the absence of knowledge of the distribution of such a ratio, it is not possible to engage in statistical testing with regard to the significance of differences from the value of 1.0, the value obtained for a market operating in accordance with the competitive norm. Consequently, the assessment of the obtained ratios is completely subjective.

The ratios for each crop year calculated on the basis of two storage costs are plotted in figure 6. The first thing to observe is the difference in actual values of the ratios depending on which storage cost level is assumed. The higher the storage cost, the lower the numerical value of the ratio, an expected result given the nature of the underlying formula used for calculations. However, the two series provide the same relative comparisons even though the associated magnitudes differ.

Starting in 1932,[26] there was a general tendency for the ratio of the coefficients to decline up to the mid-1940's, with the notable exceptions of 1934 and 1939. This suggests that during the period there was a definite tendency for the degree of variation of weekly prices about the season's average price to approach the degree of variation expected to exist in a perfectly competitive market. In other words, the cash onion market was apparently becoming more competitive during that period. Since the latter part of the 1940's, with the exceptions of 1949, 1958, 1961, and 1965, the ratio remained quite constant; an average of about 1.8 with storage costs equal to 1 cent and 1.1 with storage costs at 2 cents per sack per week.

As mentioned at the outset, considerable caution should be exercised in interpreting these ratios, particularly in an absolute sense. However, in terms of making comparisons over time they are suggestive of the direction which the performance of the onion market has followed relative to the competitive norm. On this basis, the ratios shown in figure 6 exhibit a convergence toward the competitive norm during the early part of the time period and a tendency to stay within a reasonable range since the early 1950's, with the exceptions noted.

An alternative way to view the calculated ratios is in terms of a frequency distribution. These distributions are presented in table 7, both for the entire 1930-67 period and for the three subperiods of no futures trading, futures trading, and no futures trading. Again, results are presented under alternative storage cost assumptions to show the impact of alternative cost levels on the numerical values of the ratios. Since the same relative patterns are shown under either assumption, the discussion will center on

[26] Note that 1931, as observed in previous discussions, is an extreme year.

the ratios obtained under the assumption of a storage cost of 2 cents per sack per week.

For the entire time period, the simple average ratio was 1.4, which says that on the average the actual within-season variability of weekly prices about the season's average price exceeded the variation expected on the basis of a perfectly competitive market by about 40 percent. In terms of distributional relations, a ratio of 0.8 to 1.2, which brackets the optimal value of 1.0, occurred in almost 35 percent of the cases. Almost 75 percent of the ratios fell within the range from 0.3 to 1.7. Slightly less than one ratio in five had a value in excess of 2.0.

Comparisons among the three subperiods reveal essentially the same pattern discerned in figure 6. During 1930-40, the average ratio was 1.9, implying that actual variation was about twice as large as would be expected on the basis of a perfectly competitive market. During the latter two periods, the ratio averaged about the same; 1.4 for 1949-57 and 1.3 for 1959-67. However, the distributions for these 2 years were different. During 1949-57, approximately 20 percent of the ratios fell in the 0.8-1.2 range while the comparable figure was 56 percent in 1959-67. In general, even though the average ratio was approximately the same for the two periods, smaller values occurred with a slightly higher frequency during the latter period.

CHAPTER 5. SEASONALITY IN ONION PRICES

Seasonality in prices is one of the components of within-season price variation that needs to be considered in evaluating price performance. This chapter briefly sketches the theory of an optimal seasonal price pattern for a storable commodity and investigates the possible effect that the onion futures market may have had on the seasonal pattern of onion prices.

Optimal Seasonal Price Pattern

The Theory[27]

Given the demand curves for each selling period during the storage season, the price for a seasonally produced commodity is expected to rise during the storage-selling period by the cost of storage. Ideally, merchants and farmers would correctly forecast future demands for the commodity relative to the fixed supply available at the beginning of the storage season so that they would optimally allocate this fixed supply over the season. The storage decisions would be based on the relation between the price expected in the future, P_f, and the current cash price, P_c. If e is the cost of storage between two periods then storage will take place as long as $P_f - P_c \geqslant e$. Given this simple argument, the seasonal price pattern for cash onions would be as shown in figure 7 where the rise in price from P_1 to P_2 would be equal to the cost of storing the commodity from time t_1 to time t_2.

Deviation From Optimal Seasonal Pattern

While this theory predicts a specific seasonal price pattern that is expected to recur from year to year, an examination of actual onion prices will quickly reveal that such is not the case. There are many reasons why the actual seasonal pattern of onion prices will deviate from that predicted by the theory. These underlying causes may be classified into two groups—those associated with conditions unique to a particular marketing year and those associated with changes in the structural characteristics of the onion market. Several illustrations are presented below.

Factors Unique to a Particular Year. For a relatively perishable commodity such as onions, crop quality is of extreme importance in determining storage life. When unfavorable weather during the growing season or during the harvest period results in an onion crop going into storage that is of low quality, it must move quickly into market channels to avoid a complete loss. This, of course, means that the seasonal shipment pattern will deviate from the normal pattern, with an associated deviation from the optimal price pattern. In a similar vein, even though a high quality crop may go into storage, unfavorable storage conditions could lead to a faster-than-normal breakdown in the stored crop. This would have the effect of reducing the marketable supply of onions, and a distortion of the actual seasonal pattern of prices relative to the optimal would be expected.

The theory sketched above is based on the assumption that farmers and merchants correctly anticipate seasonal demands as they make their storage-selling decisions. Consequently, to the extent that unanticipated shifts in demand occur during the season, prices will deviate from those expected.

Finally, a factor contributing markedly to year-to-year changes in the seasonal price pattern of late summer storage onions is the magnitude, as well as the arrival time on the market, of the early spring onion crop grown in Texas. Ideally, price should perform seasonally in such a way as to assure a continuous supply of storage onions until the new-crop supplies become available, but at the same time to assure that the quantity of storage stocks remaining when this new supply becomes available is minimized. Thus, in years when the Texas crop is expected to be short or when it is expected to arrive on the market later than normal, the price for storage onions would rise faster than optimal in order to ration the existing supply of onions. The converse would be true in the case of a large or early Texas crop.

Structural Changes in the Onion Market. Superimposed on the unique factors causing year-to-year changes in the seasonal price pattern for storage onions are structural changes in the market itself, which may occur abruptly or only over a long period of time, that will have a decided impact on seasonal patterns. For example, changes in storage technology affecting storage life, and ultimately storage costs, will affect the amount by which price would be expected to rise seasonally.

Increases in the size and specialization of onion farms may affect seasonal patterns. There is evidence to suggest that a "typical" onion farm is becoming so large, in terms of total production, that the farmer—storer must begin shipping out of storage soon after the completion of harvest. He must also maintain a relatively high and constant shipping rate throughout the season,

[27] For a detailed presentation of the theory see R. G. Bressler, Jr. and R. A. King, *Markets, Prices and Interregional Trade*, John Wiley & Sons, 1970, chapter 11. For an outline of this theory see the previous chapter.

THEORETICAL SEASONAL PRICE INCREASE FOR STORED ONIONS

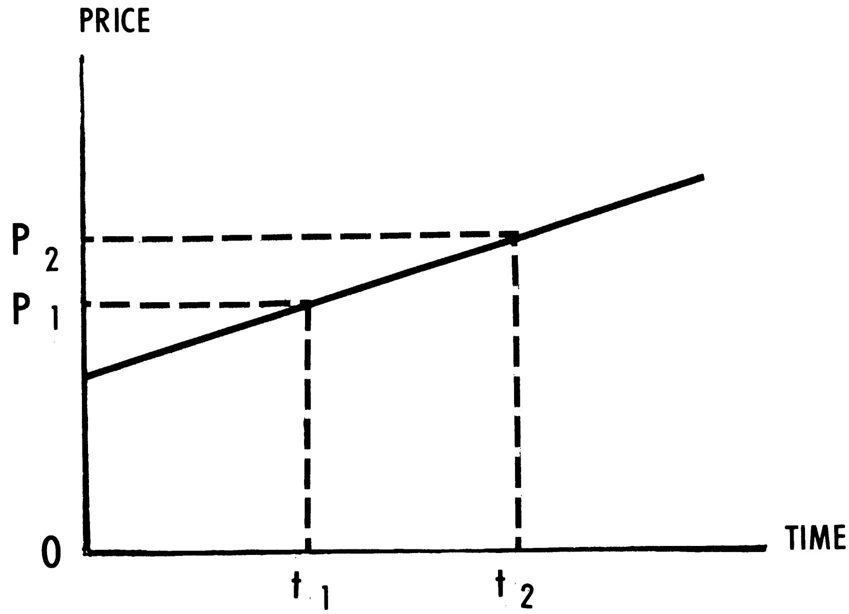


Figure 7

to liquidate his inventory prior to the planting of the following year's crop. Such changes in shipping patterns will affect seasonal price patterns.

The quantity and quality of market information available to market participants is an important determinant of price behavior. The greater the amount of information available and the higher its quality, in the sense of accurately portraying existing and expected conditions, the greater the probability that an optimal storage-selling decision will be made. In the context of the theory above, improvements in both the quantity and quality of market information would result in the actual seasonal pattern converging toward the optimal.

Finally, the structural change of particular importance in this study is the presence or absence of a futures market in onions. The next section explores the question of the probable impact of such an institution on the seasonal price pattern and the following sections present some empirical evidence relating to onion prices.

Impact of Futures Market on Seasonal Price Patterns

Unfortunately for the study at hand, there is no well-developed and empirically substantiated theory relating to the impact of a futures market on the seasonal pattern of cash prices. In general, students of futures markets have argued that the effect of such markets is to raise prices at the beginning of the storage season and to lower them at the end of the season or, in other words, to dampen the seasonal price rise. In addition, the seasonal pattern would be expected to exhibit considerable stability from year-to-year.

This characteristic of stability within and among years is based on the presumption that futures markets do two things: Eliminate uncertainty and permit arbitrage. By removing uncertainty, futures markets eliminate one "cost" of storage so that the expected seasonal price rise required to induce storage in the first place is reduced. In addition, by creating the possibility of arbitrage between two markets separated by time, the seasonal price change should be brought into equality with the cost of storage. To the extent that the explicit, or money, costs of storage vary little, or at the most slowly, over time, then the seasonal price pattern should vary little, if any, over time. However, since the "cost" associated with presence (or absence) of uncertainty escapes easy quantification, it is difficult, if not impossible, to accept or reject this presumption. In addition, because of the asymmetry involved in markets separated by time and because of the difficulty of empirically defining storage costs, particularly for onions where there is no mature "storage industry" as there appears to be for such commodities as feed grains, the efficacy of arbitrage in equating price rises with storage costs is of questionable relevance. Consequently, one is left with few, if any, theoretical reference points for interpreting observed seasonal price patterns in the context of a futures market. About all that can be done is first to examine such patterns to see if they have been changing over time and then to draw whatever inferences seem warranted. This is done in the following sections.

Previous Research on Onion Price Seasonality

Two research papers have been published relating to the impact of futures trading on the seasonal pattern of onion prices. A brief review of these papers and the conclusions drawn therein is presented in the following two sections.

Working's Paper

The first detailed analysis of the seasonal pattern in onion prices, where interest focused on the impact of the onion futures market on seasonality, was published by Working in 1960.[28] The crop years, September through March, for 1930 to 1958 provided the data set for the analysis and monthly indexes were calculated. The total period was decomposed into three subperiods for purposes of comparison: A period of no hedging, 1930-40; a period of little hedging, 1946-48 and 1958; a period of substantial hedging, 1949-57. Prices were deflated to the 1947-49 price level and the seasonal indexes were caculated for each month from September through March, with the September-March average equal to 100. Monthly price indexes were calculated for two onion price series: U.S. average farm price and western Michigan price to growers.

The seasonal index for the U.S. average farm price for onions is shown in table 8. It is clear that the seasonal pattern during years of substantial hedging was flatter than during the other two classes of years. The price index rose 40.4 points in 1949-57 and 62.9 and 61.4 points for the other two periods. The indexes for the years of little hedging were similar to those obtained from years of no hedging.

[28] Working, H., "Price Effects of Futures Trading," Food Res. Inst. Studies, Stanford Univ., Vol. I, No. 1, Feb. 1960.

The seasonal indexes for the western Michigan price to growers are presented in table 9.

This price series exhibits the same seasonal price pattern as did the previous price series. The index during years of substantial hedging rose only 21.5 points, compared with 61.4 and 93.8 points respectively during years of no hedging and little hedging.

For both price series, futures trading in onions appeared to have reduced the degree of seasonal variation in onion prices. From these results, Working concluded that the theory[29] concerning the impact of futures trading on within-season price variation had been substantiated.

Gray's Paper

A second investigation of the seasonal pattern of onion prices was published by Gray in 1963,[30] when onion price data became available for a period of years following the congressional ban on futures trading in onions. The basic question considered by Gray was what happened to price seasonality since the imposition of that ban. Since the results of a similar analysis are presented in the following section, only his methodology and conclusion are presented here.

In his paper Gray presents seasonal indexes for the U.S. farm price of onions for four periods: 1922-41, 1942-49, 1949-58, and 1958-62. The first three periods correspond approximately to Working's classes of no hedging, little hedging, and substantial hedging, respectively. The last period, 1958-62, represents the 4-year period following cessation of trading in onion futures. By comparing the indexes for these four periods, Gray demonstrated that the seasonal price pattern during 1958-62 had reverted back to the pattern observed during the periods of little or no hedging in onions. He concluded that this added further substantiation to the argument that the effect of futures trading is to dampen within-season price variation.

An Updating of Gray's Analysis

Gray's analysis has been updated by calculating the seasonal index of the U.S. farm price of onions for the crop years from 1962 to 1968 using the same method of calculation. The results of these calculations along with

[29] See *Impact of Futures Market on Seasonal Price Patterns* above.

[30] Gray, R., "Onions Revisited," Jour. Farm Econ., Vol. 45, No. 2, May 1963.

Table 8.—Index of average seasonal variation in U.S. farm price of onions during September-March for selected periods, crop years 1930-58[1]

Month	No hedging, 1930-40	Little hedging, 1946-48 and 1958	Substantial hedging, 1949-57
September	77.0	63.1	80.3
October	75.4	70.1	86.6
November	79.5	82.3	97.2
December	96.3	90.3	100.2
January	109.0	106.1	106.0
February	122.9	128.3	108.9
March	139.9	159.7	120.7

[1] September-March average = 100.

Source: Working, H., "Price Effects of Futures Trading," Food Res. Inst. Studies, Stanford Univ., Vol. I, No. 1, Feb. 1960, table 4, p. 12.

Table 9.—Index of average seasonal variation in western Michigan price to onion growers during September-March for selected periods, crop years 1930-58[1]

Month	No hedging, 1930-40	Little hedging, 1946-48 and 1958	Substantial hedging, 1949-57
September	79.7	68.3	87.0
October	78.5	74.0	94.6
November	82.4	87.6	102.5
December	97.0	89.9	98.2
January	104.9	101.1	103.6
February	116.4	117.0	105.9
March	141.1	162.1	108.5

[1] September-March average = 100.

Source: Working, H., "Price Effects of Futures Trading," Food Res. Inst. Studies, Stanford Univ., Vol. I, No. 1, Feb. 1960, table 4, p. 12.

Table 10.—Index of seasonal variation in U.S. average farm price of onions during September-March for selected periods, crop years 1949-68[1]

Month	Hedging, 1949-57	No hedging	
		1958-61	1962-68
September	80.0	70.4	91.1
October	87.1	74.7	91.3
November	98.1	77.4	96.2
December	100.2	86.0	95.3
January	105.9	113.1	104.1
February	108.6	130.2	105.3
March	120.1	148.2	116.7

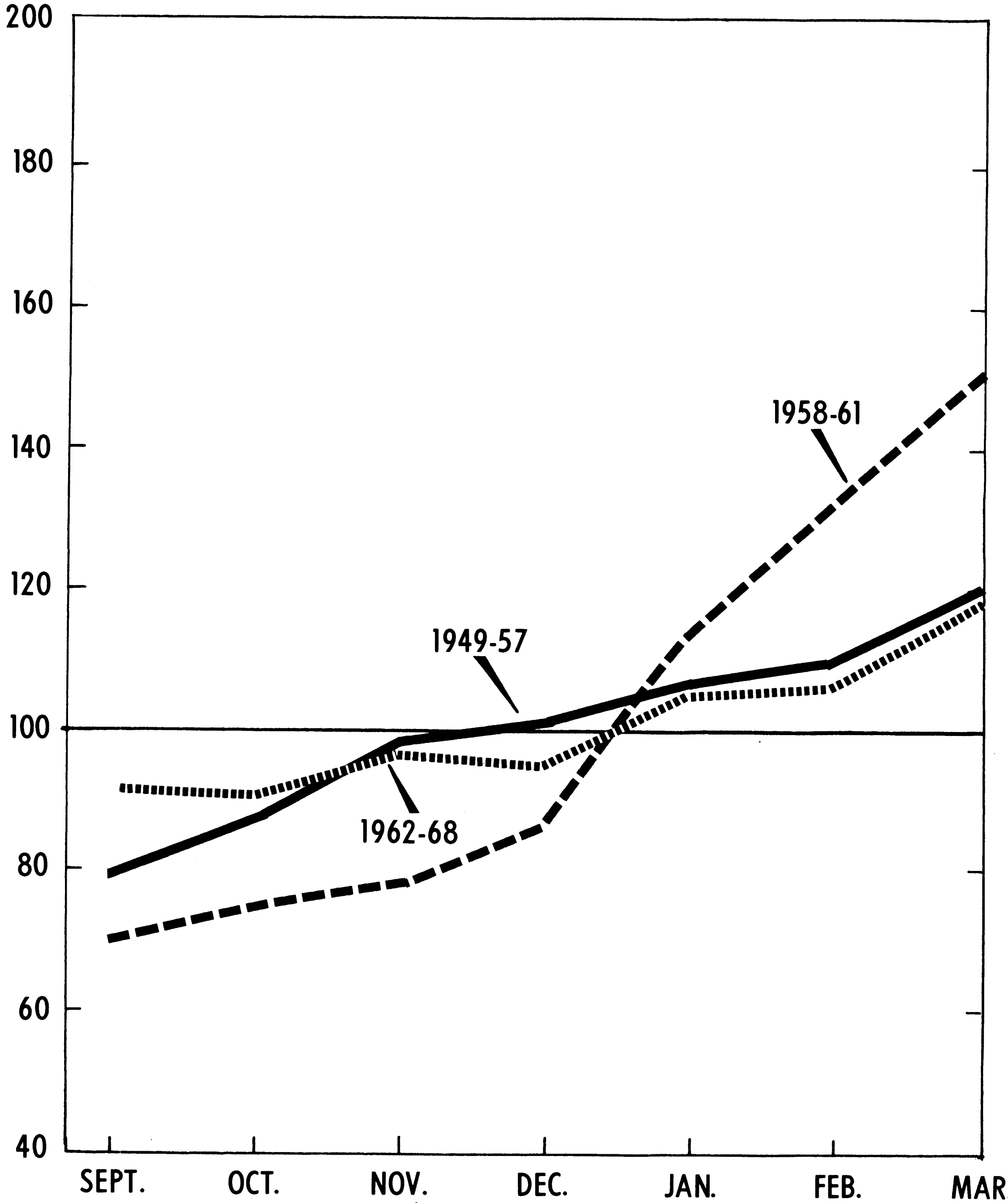
[1] September-March average = 100.

the indexes for 1949-57 (Working's period of substantial hedging) and 1958-68 (the period of Gray's analysis) are presented in table 10 and figure 8.

The basis for the conclusion that seasonality increased following cessation of futures trading in onions, the period of data available to Gray at the time of his study, is clearly apparent. During the period of substantial futures trading, the seasonal index, on the average, rose from 80 in September to 120 in March for an overall gain of 40 index points. For the following 4 years (period of Gray's analysis), however, the index rose from about 70 in September to 148 in March, an increase of almost 80 index points. In other words, following the ban on onion futures trading, prices tended to rise seasonally almost twice as rapidly as they had during the period of substantial hedging.

The finding of significance in the current analysis, however, is that since 1961 the seasonal pattern of onion prices has been almost identical with that which existed during the period of substantial hedging. For the 1962-68 crop years, prices rose seasonally, on the average, from an index of 90 in September to 117 in

INDEX OF SEASONAL VARIATION IN U.S. AVERAGE FARM PRICE OF ONIONS

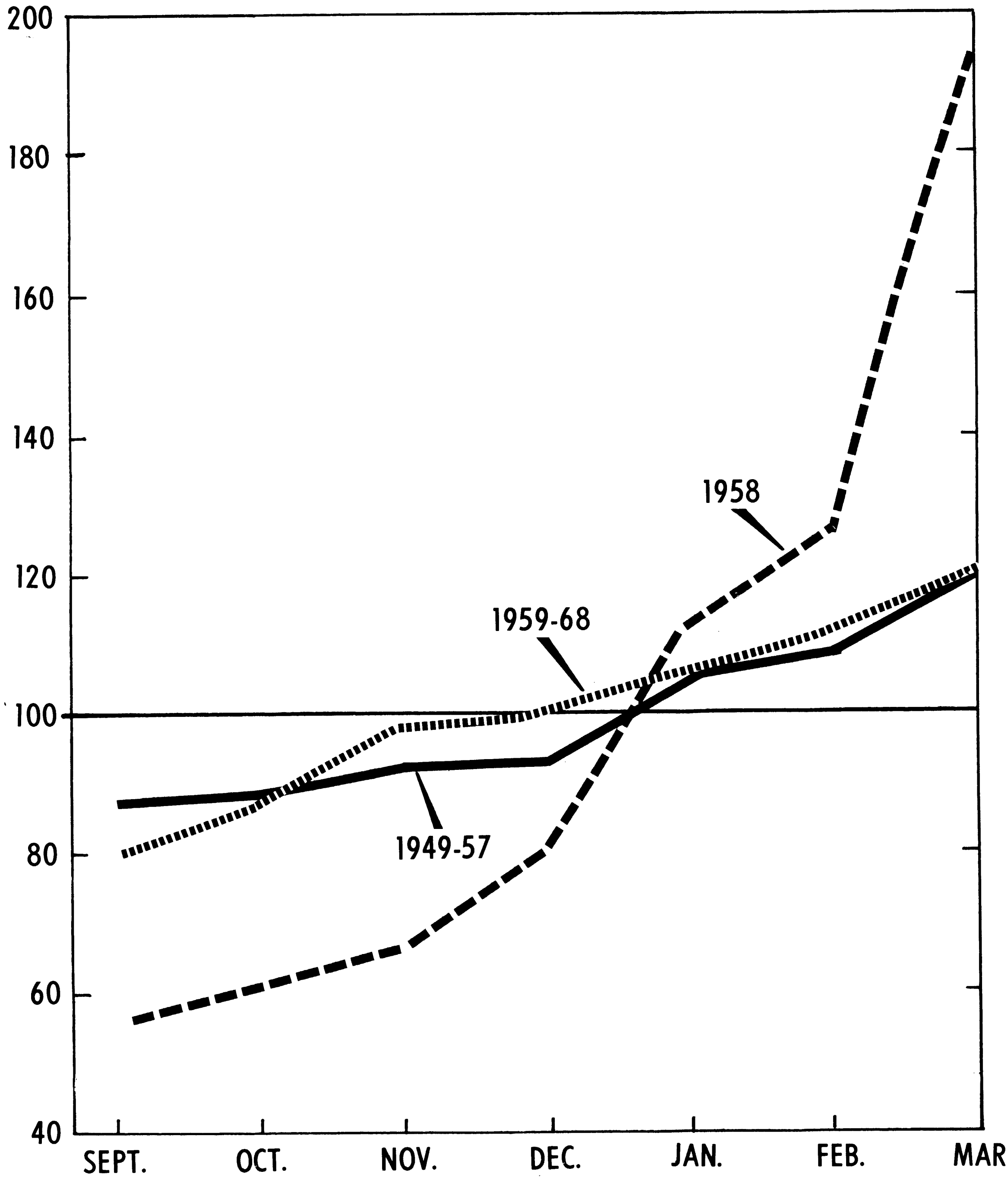


SEPTEMBER -MARCH AVERAGE PRICE = 100.

PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910 - 14 = 100.

Figure 8

INDEX OF SEASONAL VARIATION IN U.S. AVERAGE FARM PRICE OF ONIONS



SEPTEMBER - MARCH AVERAGE PRICE = 100.

PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910 - 14 = 100.

Figure 9

March compared with a rise from 80 to 120 during 1949-57. In addition, for 6 of the 7 months during the season, the indexes for these two time periods differ by five index points or less.

A more detailed analysis of the seasonal price patterns of the farm price of onions on a year-to-year basis was undertaken in an attempt to rationalize the results shown above. This analysis revealed that the 1958 crop year had the largest seasonal increase in prices of any crop year during the 20-year period 1949-68. This is illustrated in figure 9 which shows the indexes for 1949-57, 1959-68, and 1958. As can be seen, the indexes for the periods prior to and following 1958 are extremely close. These results strongly suggest that, with the exception of one year, the seasonal pattern in the farm price of onions remained relatively stable for 20 years; a period characterized by 9 years of substantial hedging and 10 years with no hedging.

The 1958 crop year was somewhat unique for at least two reasons. First, it was characterized by Working as a year of "little hedging." Since it was the last full crop year for which hedging was possible, it was essentially a transitional year. Second, an analysis of the statistics pertaining to this crop year revealed the following: The per capita production of 9.50 pounds of late summer onions was the third smallest during the 20-year period; the smallest was 9.37 pounds in 1966 and the second smallest was 9.41 pounds in 1964. The March 1 estimate of spring production, which becomes available on the market at about the end of the late summer storage season, of 1.04 pounds per capita was the second smallest for the 20-year period; the smallest was 0.59 pound in 1950. In addition, this represented the third largest decline from the previous year's spring production during this period. In summary, conditions for the 1958 late summer onion crop were optimum for the rapid seasonal increase in prices that occurred.

The result of this updating is to suggest strongly that, with the exception of the transitional year (1958), there appears to have been no substantial variation in the seasonal price pattern of the U.S. farm price for onions from 1949 to 1968.

Seasonality in Weekly Onion Prices

The analysis in this section differs from the previous one in two respects: An f.o.b. shipping point price is used, and the seasonals are based on weekly rather than monthly prices. To adjust for calendar difference from year-to-year, weeks were standardized on the basis of the week number within the shipping season. The seasonal pattern is portrayed for three periods, 1930-40, 1949-57, and 1959-67, using average prices for each week during the appropriate periods. Only weeks were used for which there were prices for all of the years in the time period. Indexes were determined for both Michigan f.o.b. and New York f.o.b. prices and are shown in figures 10 and 11. Since the patterns for these two series are very similar, the discussion will focus only on the Michigan series.

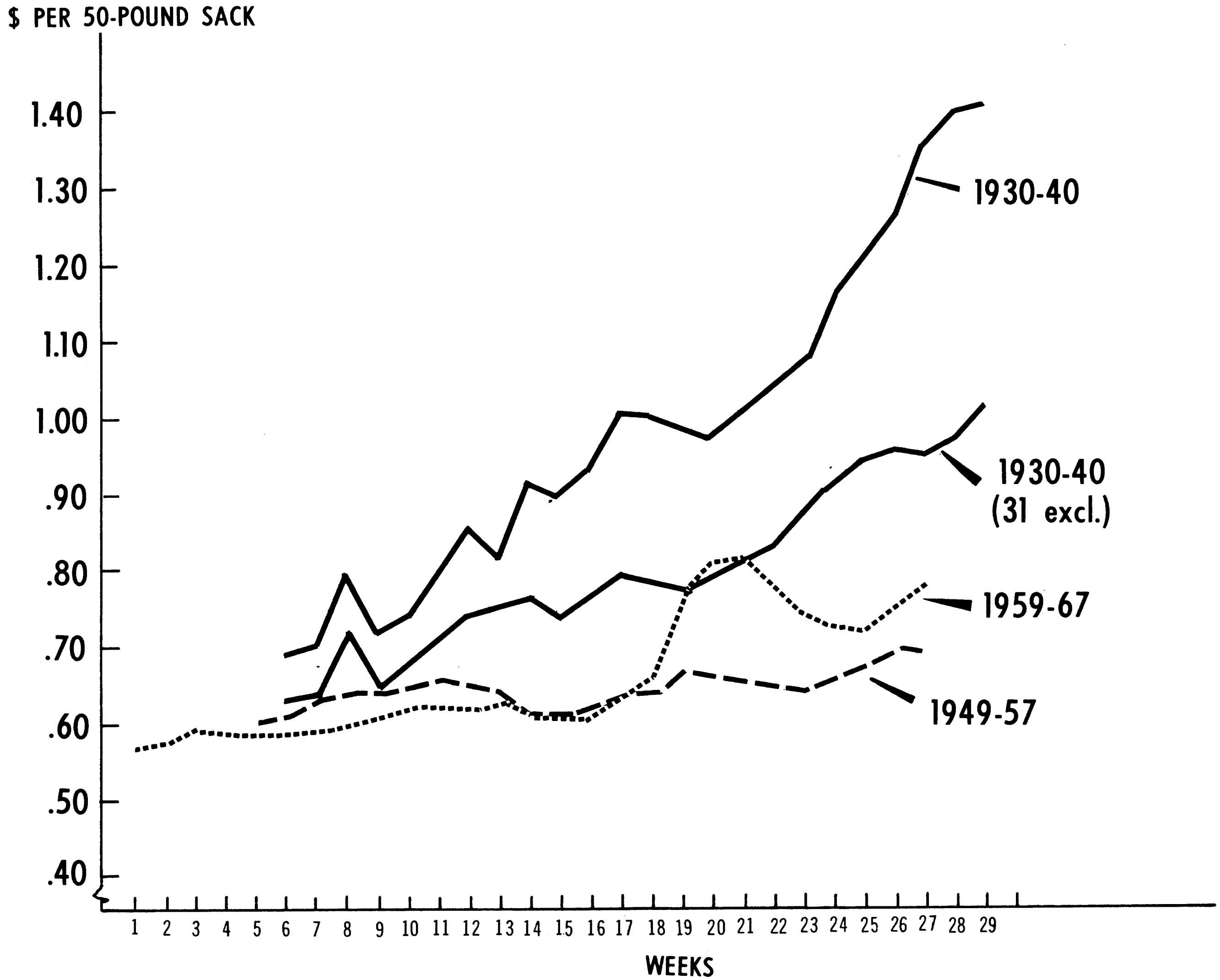
The same general seasonal pattern observed in the previous sections is evident. Price rose by a substantially greater amount during 1930-40 than it did in either of the other two periods. In fact, with minor exceptions, the seasonal pattern for these two periods coincides. One thing done here that was not done in the previous sections was to calculate the index for 1930-40 omitting the 1931 crop year, which was decidedly different from the other 10 year in this period. Due to many unusual circumstances, price during this year averaged much higher than any other years included in the analysis[31] and the seasonal price rise was by far the largest. With this year eliminated, the seasonal for this period is remarkably similar to that for the other periods. In fact, on the basis of the simple graphic comparison one is tempted to conclude that the seasonal price pattern for onions remained remarkably stable from 1930 to 1967.

Changing Price Seasonals

The comparisons in the previous sections used seasonal indexes based on averages over a period of years and, therefore, may be suspect to the extent that these averages are strongly influenced by only 1 or 2 years during the period on which the average is based. It could be, for example, that during a period of 10 years, there were 8 during which price did not change from month to month and 2 during which price rose dramatically during the season. In such a case, the index based on averages could show a strong seasonal pattern in prices even though the "typical" situation was one of no seasonal price change. This section investigates this possibility by considering the 1949-57 and 1959-68 periods on a year-to-year basis. The purpose is to detect whether or not substantial shifts in the seasonals occurred. If they did occur, then the validity of the comparisons of the previous sections becomes questionable. The U.S. farm price for onions, deflated by the index of prices received, is used and the seasonal for a particular month in a given year is the price for that

[31] See table 1, chapter 4.

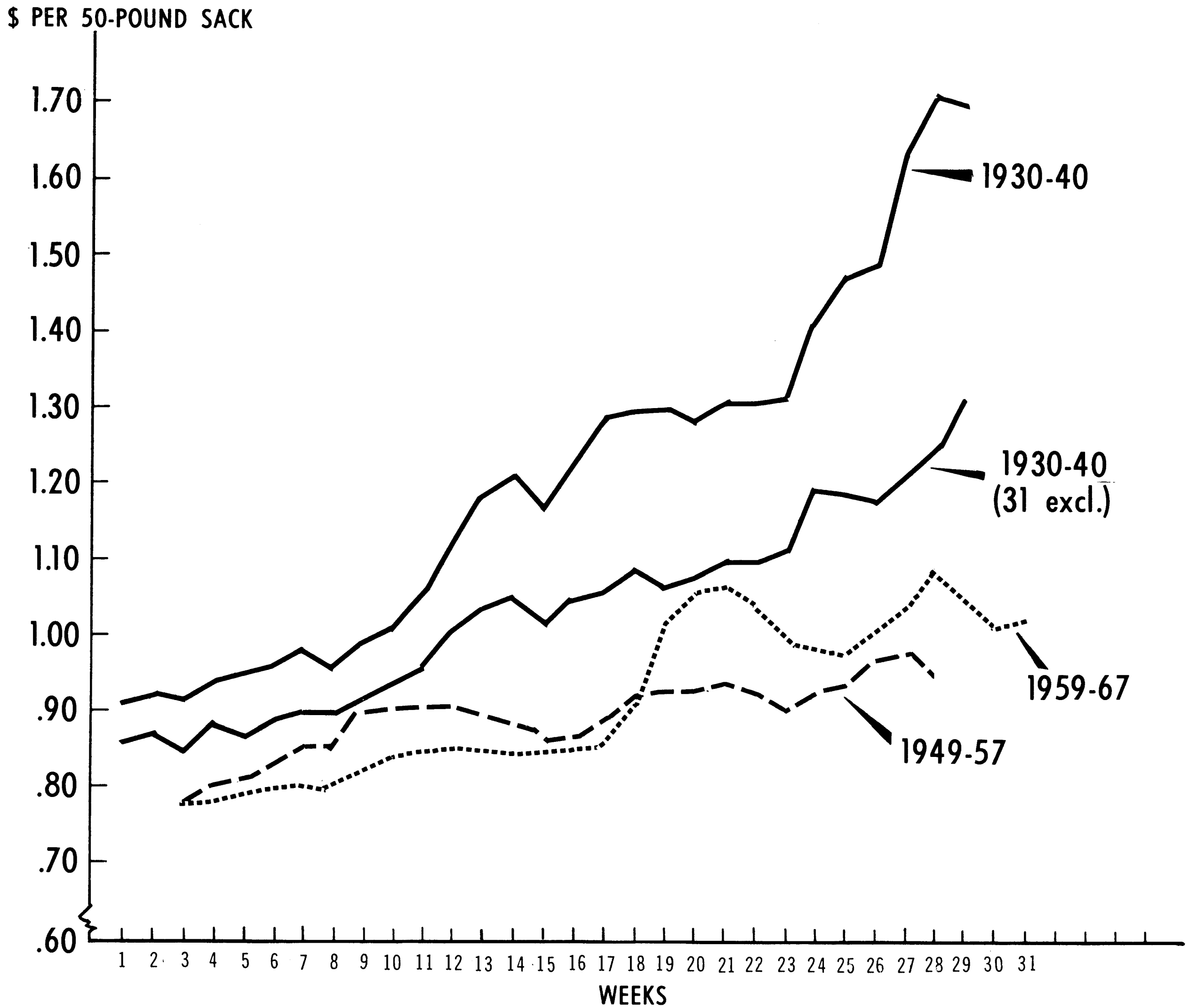
SEASONAL PATTERN IN WEEKLY MICHIGAN f.o.b. CASH ONION PRICES



PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910-14 = 100.

Figure 10

SEASONAL PATTERN IN WEEKLY NEW YORK f.o.b. CASH ONION PRICES



PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910-14 = 100.

Figure 11

Table 11.—Frequency distribution of monthly price seasonal (monthly price as percentage of annual average), U.S. farm price of onions, crop years 1949-57 and 1959-68[1]

Month and period	Price seasonal				
	Less than 90	90-99	100-109	110-119	Over 119
September:					
1949-57	0.33	0.33	0.22	0.11	0
1959-68	.40	.30	0	.20	.10
October:					
1949-57	.56	.11	.11	.22	0
1959-68	.50	.10	.20	.20	0
November:					
1949-57	.44	0	.11	.33	.11
1959-68	.40	.20	.30	.10	0
December:					
1949-57	.33	.22	.11	.22	.11
1959-68	.50	.10	.30	.10	0
January:					
1949-57	0	.44	.33	.22	0
1959-68	.10	.40	.30	0	.20
February:					
1949-57	.33	.11	0	.11	.44
1959-68	.30	0	.20	.20	.30
March:					
1949-57	.22	.11	.11	.11	.44
1959-68	.10	.10	.30	.10	.30

[1] Rows will not necessarily sum to 1.00 because of rounding.

month expressed as a percentage of the annual average price for that year.

The seasonals for each month are shown in figure 12 by crop years, with 1958 omitted. Over the entire period from 1949 to 1968, there has been no overall tendency for price in any particular month to persistently increase or decrease relative to the season's average price. In other words, there is no apparent trend in the seasonals, although substantial year-to-year variation is evident. Price during the last 2 months of the storage season, March in particular, has varied considerably with respect to the annual average. This variation appears to have been offset during September-November; when the March price is relatively high the early season price is relatively low and vice versa, as it would have to be by virtue of the method used to calculate the seasonals. However, the observation made above is of relevance here; namely, there is no apparent long-run trend in seasonals.

A month-by-month comparison of the seasonals for the two separate periods lends further substantiation to this observation. If, for example, the September seasonals for the two periods were superimposed, with 1959 placed on 1949 and so on, the two series would practically coincide. Similar results would be obtained for the other 6 months. March would be, to some extent, a major exception although the general pattern of movement would be the same.

Through the use of a frequency distribution, it is possible to determine whether particular values of the seasonals occurred with similar frequencies during the two different time periods. These distributions are presented in table 11. Overall, the distribution between the two time periods is remarkably similar on a month-by-month comparison, for the early months of the storage season. As in the above comparison, March tends to differ somewhat as there is a slight tendency for a greater frequency of larger values in the first period.

In summary, it appears that even on a year-to-year comparison there was not a marked shift in the seasonal pattern of onion prices between 1949-57 and 1959-68. The comparisons made in this section lend validity to the analyses and conclusions of the previous sections.

Conclusions

Updating of the Working and Gray studies by utilizing more recent price data strongly suggests that, with the exception of 1958 which may be viewed as a transitional year, the seasonal pattern of onion prices has remained unchanged since the ban on futures trading.

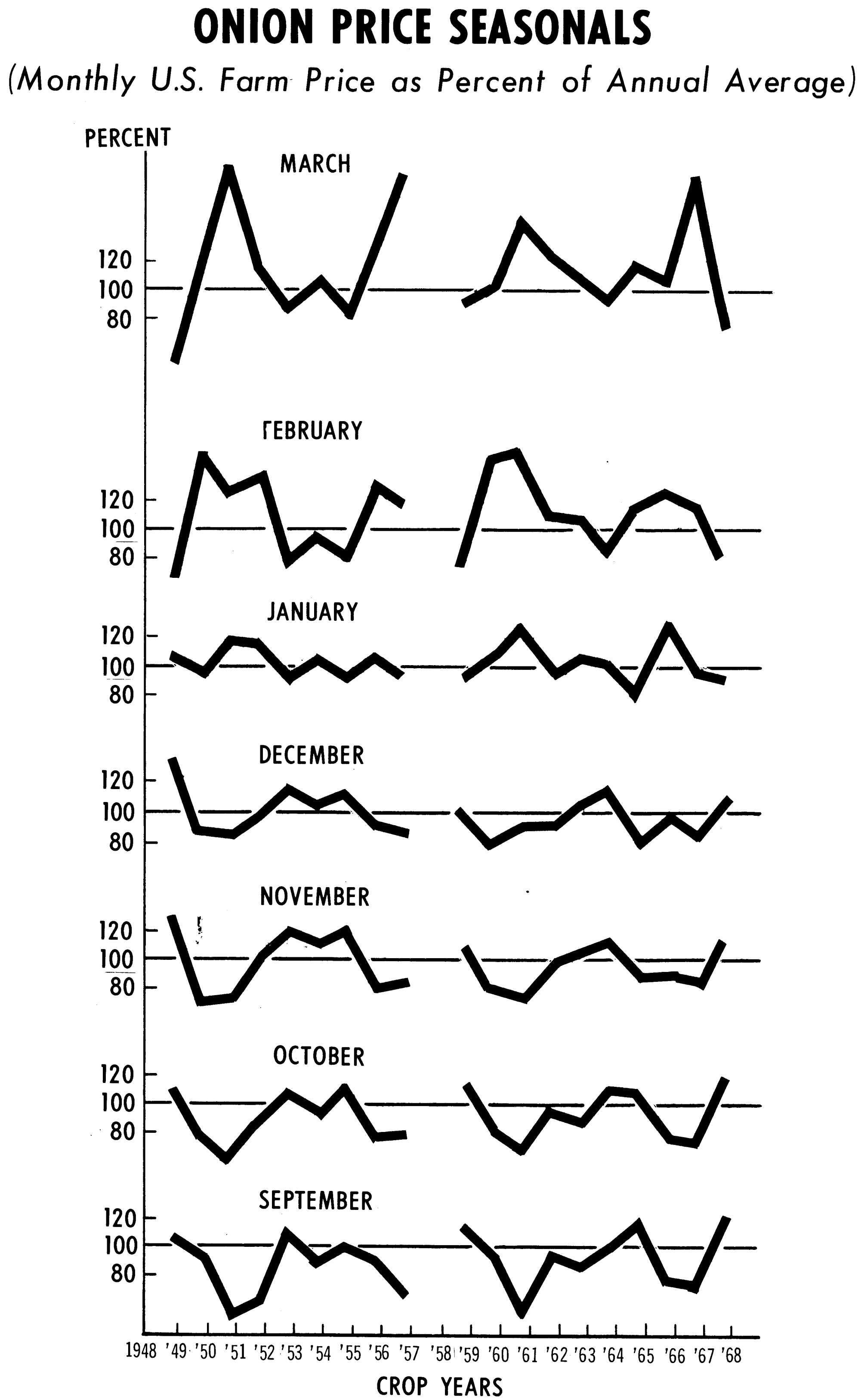

ONION PRICE SEASONALS
(Monthly U.S. Farm Price as Percent of Annual Average)
PERCENT
MARCH
FEBRUARY
JANUARY
DECEMBER
NOVEMBER
OCTOBER
SEPTEMBER
120
100
80
1948 '49 '50 '51 '52 '53 '54 '55 '56 '57 '58 '59 '60 '61 '62 '63 '64 '65 '66 '67 '68
CROP YEARS

Figure 12

The same conclusion seems to apply whether using the farm price or an f.o.b. shipping point price and whether using monthly or weekly price indexes.

For the three periods from 1930 to 1968, the general conclusion is that the average seasonal price rise before futures trading began was substantially greater than during and after futures trading, and that the average seasonal price rise during the latter two periods was the same. In other words, a decided shift in the structure of seasonality occurred between the first and second periods and persisted during the third period. However, if the index for the first period, 1930-40, is calculated omitting 1931, it is not so obvious that such a structural shift did, in fact, occur.

It is not at all clear that the presence of the futures market in onions had any perceptible impact on the seasonal pattern in cash onion prices. The data presented in this chapter strongly suggest that it had none.

CHAPTER 6. WITHIN-MONTH PRICE VARIATION

The Process of Price Discovery[32]

Price Discovery As Price Forecasting

In the markets of theory, price is *determined* by the interaction of supply and demand forces. In the markets of the real world, price must be *discovered* by the many market participants involved in buying, selling, processing, and storing the commodity as it moves through the marketing system from the primary producer to the final consumer. This characteristic of real-world markets is a manifestation of the inadequacies and imperfections in these markets, not the least of which is the fact that the market participants do not, at any given point in time, possess the requisite information to move directly to the market-clearing price, but rather they must seek out that price through their buying and selling activities. In other words, price discovery is really price forecasting.

As market participants perform the various marketing activities associated with moving a commodity through the marketing system they are, in essence, attempting to forecast what the price will be when it reaches the retail market. It is on the basis of this forecasted price that they must make their business decisions. Since these forecasts pertain to the future they necessarily rest on the judgment of the individuals involved; judgments that must be formed on an assessment of current market information. As in any situation when an uncertain future is involved, some market participants will make good judgments and some will make poor judgments, with the consequence that over time those who consistently make poor judgments will go out of business. Even for those who remain, however, mistakes will be made from time to time, mistakes that are likely to be rooted in market information that is either in error or incomplete, or both. In any event, those concerned with the performance of the market as an instrument for discovering price are ultimately concerned with improving the system in order that better market information be made available to provide the basis for the making of better judgments.

[32]This section draws heavily from F. L. Thomsen and R. J. Foote, *Agricultural Prices*, McGraw-Hill Book Co., Inc., 1952, Chapters 8 and 9.

Forecasting Onion Prices

The process of price discovery, or forecasting, is particularly difficult for onions. When the late summer onion crop is harvested, farmers and merchants must decide how much to sell immediately and how much to put into storage for later sale. This decision must, of course, be based primarily on what they expect the future price to be during the storage season. Once the storage decision has been made it is necessary for them to constantly study the market to determine the rate of flow of onions out of storage. If prices are expected to decline, then there would be a tendency to speed up the rate of flow; on the other hand, if prices are expected to increase there would be a tendency to slow down the rate of flow in anticipation of the higher prices later on.

There tends to be a seasonal pattern in onion prices that relates to the cost of storage and, hence, offers the inducement to store in the first place. However, conditions unique to each year, such as storage breakdown or unanticipated shifts in demand, may cause the actual price pattern to deviate from the "normal" pattern. An important potential source of forecasting error in the onion market arises from uncertainty relating to the size and timing of the Texas onion crop that typically competes with late summer onions during the latter part of the storage season. Farmers and merchants must constantly utilize all available information concerning the Texas crop in an attempt to forecast the late-season price so that the proper quantity of storage onions is maintained to the end of the storage season.

This delicate balancing of the availability of storage onions with expected new supplies requires accurate price forecasts which, in turn, require accurate market information. When this information is incomplete or incorrect, the price discovery process will perform imperfectly, with the consequence that rather extreme, and perhaps seemingly unwarranted, variation in onion prices may occur both within a particular season and from season to season.

Price Discovery and the Futures Market

The necessity of forecasting onion prices in the presence of market characteristics that make this a particularly difficult task focuses attention on the institutional framework within which this process is carried out. By institutional framework is meant the completeness and accuracy of market information, the communication network through which this information flows, the opportunities available to farmers and merchants to respond to changes in market information, and, of course, their ability to form the "right" judgment on the basis of the available information.

Of particular interest to the current study is the question of what impact, if any, the onion futures trading had on the price discovery process in the onion market. Simplistically, it seems reasonable to suppose that the futures market would make this process more "efficient" in the sense that more accurate price forecasts would be made. Implicit in this supposition is the idea that futures markets typically provide more information, that the information is widely dispersed and readily available to all persons involved in the marketing of the commodity, and that through the possibility of hedging and speculating, market participants may respond quickly and effectively to judgments based on changes in market conditions. In practical terms, this argument suggests that, all else constant, one might expect to observe a smaller degree of seemingly unwarranted price variation in onions in the presence of a futures market. This question is considered in the sections that follow.

Price Discovery and the Monthly Price Range

To examine the question of the impact of the onion futures market on price discovery, it is necessary to develop an empirical measure that will make it possible to detect when changes have occurred in the process. For this purpose, the monthly price range—defined as the difference between the highest and lowest price occurring during a particular month—is used.[33] There is no particularly compelling reason for using this measure. However, from the standpoint of assessing price performance related to price forecasting, it does seem reasonable. If market conditions are changing rapidly and if inaccurate price forecasts have been made, then presumably, considerable price variation would occur as an attempt is made to "rectify" the error; if accurate price forecasts have been made, then little, if any, price adjustment would be required when the forecasted period arrived. The assumption here is that this type of price adjustment can be measured, at least approximately, by the monthly price range. Consequently, in the sections that follow, interest will center on both the magnitude and changes in the magnitude of the monthly price range of onions over time.

Monthly Price Ranges—An Overview

Monthly price ranges for September through March for Michigan f.o.b. cash onion prices are shown in figures 13-15 for 3 periods: Period I, 1930-40; period II, 1949-57; and period III, 1959-68. The figures show not only the monthly price range but also changes in the level of prices during the season.

While each year possesses characteristics unique to itself, some general tendencies are clearly apparent. In particular, the price range tends to increase as the marketing season progresses, with some rather extreme values occurring in February and March. This undoubtedly reflects the point made above with respect to the imminence of the Texas crop. In years when inaccurate forecasts have been made, considerable late-season price adjustment is required to effect the requisite balancing of storage and new-crop supplies of onions.

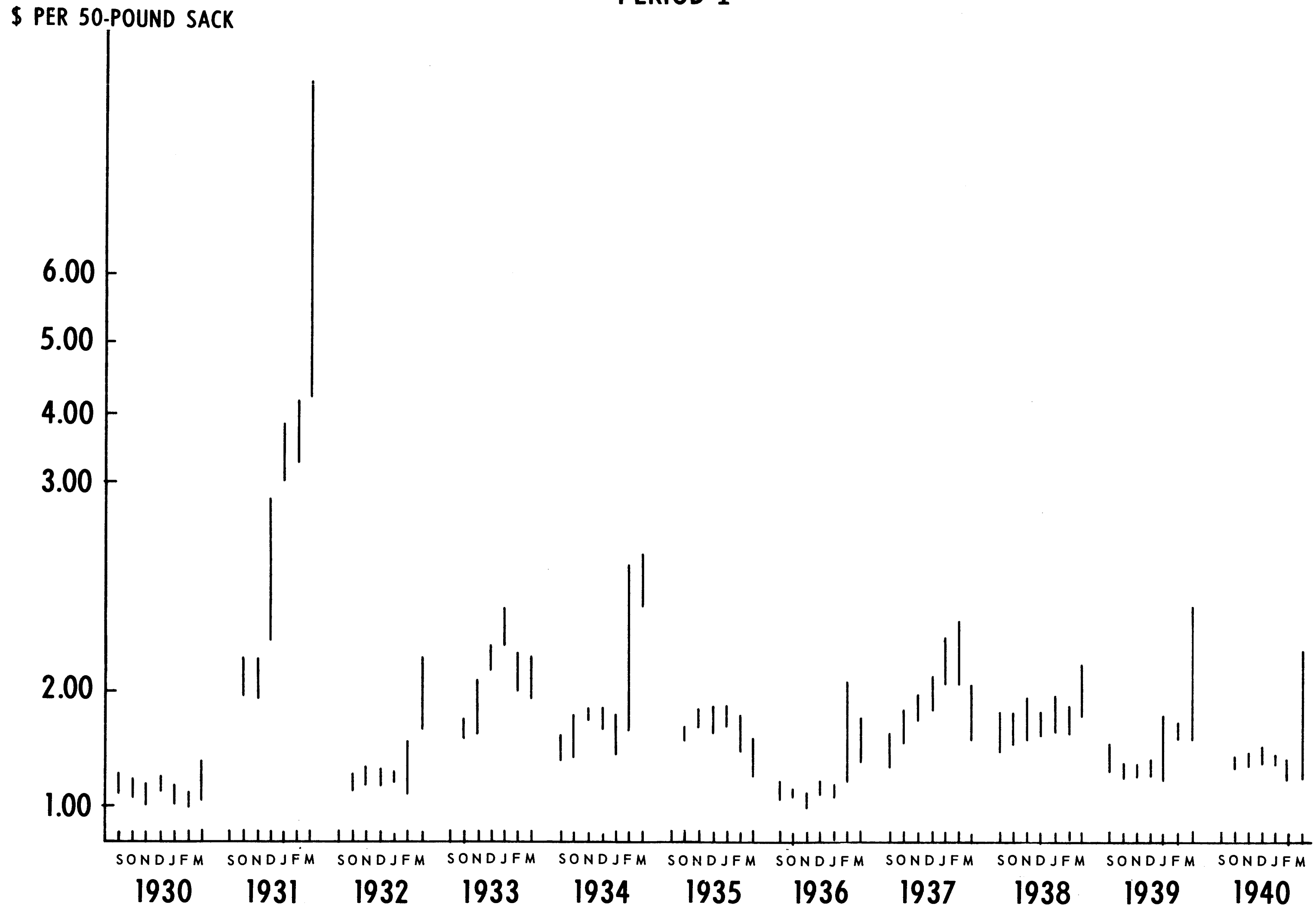
While there is an indication of this seasonal pattern in the price range, a careful examination of figs. 13-15 suggests that this pattern is conditional on other characteristics of price. In years when the level of price was rising during the season, there was a tendency for the price range to increase, while during years of generally falling price the seasonal increase in the price range was less. In addition, the extent of the seasonal change in the price range appears to be conditioned by the level of price at the beginning of the marketing season.

Such observations can, of course, be rationalized. When early season price forecasts turn out to have been correct, little price adjustment will be required to balance supplies and, consequently, prices and price ranges will follow normal seasonal patterns. On the other hand, in the presence of inaccurate forecasts, rapid, and sometimes substantial, adjustments will be required. Early season underestimates apparently result in substantial increases in both the level of price and the extent of the price range, while overestimates result in downward adjustments in the level of price and relative stability in the price range. These relationships are examined in more detail in the following section.

[33] This measure of within-month price variation was used by Holbrook Working in "Price Effects of Futures Trading," Food Res. Inst. Studies, Stanford Univ., Vol. 1, Feb. 1960, pp. 3-31. Thus, the material in this chapter is essentially an updating of his work.

MONTHLY PRICE RANGE, MICHIGAN f.o.b. CASH ONION PRICES

PERIOD I



PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910 -14 = 100.

Figure 13

MONTHLY PRICE RANGE, MICHIGAN f.o.b. CASH ONION PRICES

PERIOD II

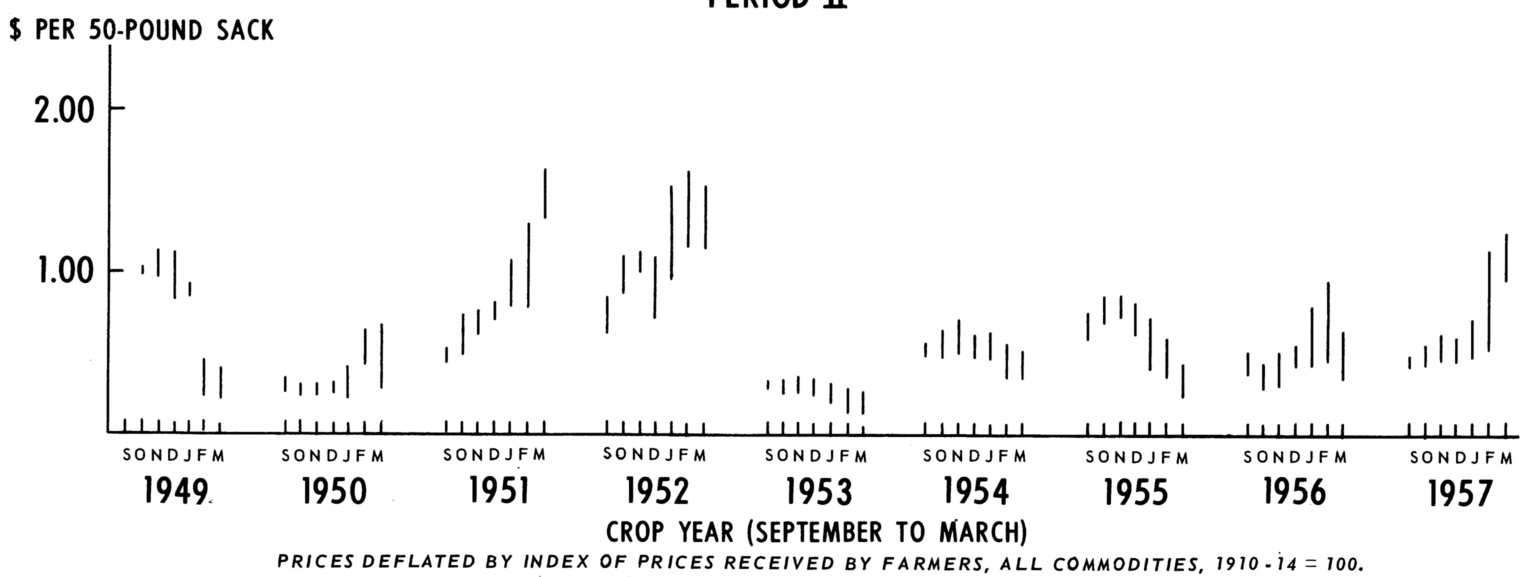
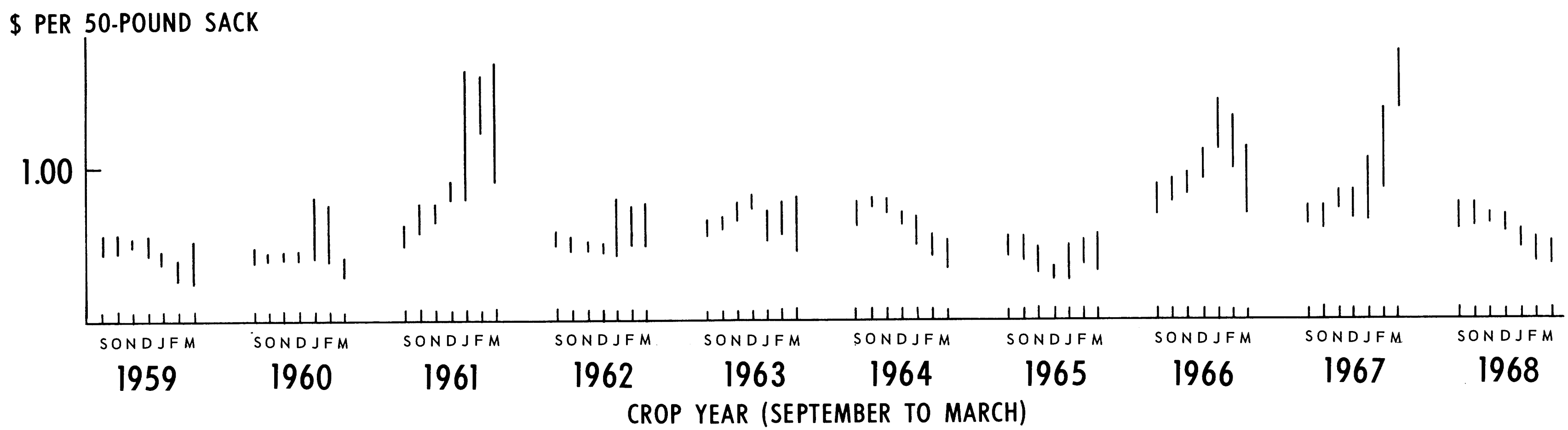


Figure 14

MONTHLY PRICE RANGE, MICHIGAN f.o.b. CASH ONION PRICES

PERIOD III



PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910-14=100.

Figure 15

The Effect of Price Level and Price Seasonality

To investigate the possible effect of the early season price and the seasonality in price on the seasonal pattern of the price range, all of the years have been cross-classified with respect to these two factors. The classification system used suffers from the same problem of most all classification schemes; namely, it is quite arbitrary. Given the same basic data set, a different researcher could develop a different scheme which might lead to quite different conclusions. For the current case, a comparison was made between the way in which the years were classified and the graphic portrayal of figs. 13-15 and it was felt that the results of the classification were acceptable for purposes of general comparison. More specific comparisons are presented later in the text.

The results of the classification are presented in tables 12 through 14. The basis for each of the tables is the price at the beginning of the marketing period. Footnotes in the tables specify the numerical values for the descriptive terms used. Before examining the seasonal pattern of the price range it would be well to briefly consider the classification of the various years in terms of the early season price and in terms of the seasonality of price.

Table 12.—Seasonal pattern of price level and price range in years with a low beginning price,[1] Michigan f.o.b. cash onions, selected periods, 1930-68

Change in price level	Change in price range		
	Increase[3]	Decrease[3]	Unchanged[3]
Increase[2]	1932,1936 1950,1956 1960,1962	--- --- ---	--- --- ---
Decrease[2]	--- --- ---	--- --- ---	--- 1953 ---
Unchanged[2]	1930 --- 1959	--- --- 1965	--- --- ---

[1] September to December median price less than $0.50 per 50-pound sack.
[2] Increase = more than +0.10; decrease = more than -0.10; unchanged = less than ±0.10.
[3] Increase = more than +0.05; decrease = more than -0.05; unchanged = less than ±0.05.
NOTE: First line in cell is period I
Second line in cell is period II
Third line in cell is period III

Table 13.—Seasonal pattern of price level and price range in years with a moderate beginning price,[1] Michigan f.o.b. cash onions, selected periods, 1930-68

Change in price level	Change in price range		
	Increase[3]	Decrease[3]	Unchanged[3]
Increase[2]	1934, 1937, 1938, 1939, 1940 1951, 1957 1961, 1967	--- --- ---	--- 1952 ---
Decrease[2]	1935 1955 ---	--- --- ---	--- 1949, 1954 1964, 1968
Unchanged[2]	--- --- 1963, 1966	--- --- ---	--- --- ---

[1] September to December median price $0.50-$1.00 per 50-pound sack.
[2] Increase = more than +0.10; decrease = more than -0.10; unchanged = less than ±0.10.
[3] Increase = more than +0.05; decrease = more than -0.05; unchanged = less than ±0.05.
NOTE: First line in cell is period I
Second line in cell is period II
Third line in cell is period III

Table 14.—Seasonal pattern of price level and price range in years with a high beginning price,[1] Michigan f.o.b. cash onions, selected periods, 1930-68

Change in price level	Change in price range		
	Increase[3]	Decrease[3]	Unchanged[3]
Increase[2]	1931 --- ---	1933 --- ---	--- --- ---
Decrease[2]	--- --- ---	--- --- ---	--- --- ---
Unchanged[2]	--- --- ---	--- --- ---	--- --- ---

[1] September to December median price more than $1.00 per 50-pound sack.
[2] Increase = more than +0.10; decrease = more than -0.10; unchanged = less than ±0.10.
[3] Increase = more than +0.05; decrease = more than -0.05; unchanged = less than ±0.05.
NOTE: First line in cell is period I
Second line in cell is period II
Third line in cell is period III

Classification of Years by Early Season Price

Overall, 10 years were classified as having a low early season price, 18 with a moderate early season price and 2 with a high early season price. Among the three periods, the distribution was about the same; the 10 low-price years consisted of 3 years from period 1, 3 from period II, and 4 from period III; the 18 moderate-price years consisted of 6 years from each of the three periods; the 2 high-price years occurred in period I. Taking the alternative view, during the first period, 3 of the 11 years were characterized by a low early season price, 6 by a moderate price, and 2 by a high price. For the second period, 3 years had low prices and 6 had moderate prices. Finally, the third period was characterized by 4 years of low early season prices and 6 years with moderate prices. Thus, it appears that the general level of prices during the early part of the storage season was comparable among the three time periods, the exception being that the 2 years with high prices occurred during 1930-40.

Classification of Years by Change in Price Level

Quite a different situation existed with respect to changes in price level during the storage season. For 18 of the 30 years, the median price between early season (September–December) and late season (February–March) increased more than $0.10 per 50-pound sack, 7 showed a decrease, and 5 remained unchanged. Of the 18 years of rising prices, 9 occurred in period I, 5 in period II, and 4 in period III. Alternatively, of the 11 years in period I, 9 were years in which price increased between early season and late season. This contrasts with 5 of 9 years with price increases in period II and 4 of 10 in period III. Of the 9 years in period II, price increased in 5 and decreased in 4. In period III, a different pattern emerges; 4 years involved price increases, only 2 had price decreases, and in 4 years the difference between the early and late season price was less than $0.10 per 50-pound sack.

In general, while early season prices were comparable among the three periods, there was a definite tendency for substantial seasonal price increases to occur during the first period as contrasted to the later two periods. This is, of course, the relationship detected in the previous chapter. This is considered in more detail in a later section.

Seasonal Pattern of the Price Range

The relation between the change in the level of price during the storage season and the change in the price range is shown in table 15. For the 30 years considered, the price range increased in 22, decreased in 2, and remained unchanged in 6. Of the 22 years when the price range increased, 16 were associated with an increase in the price level, 2 with a decrease in the price level, and 4 with no seasonal change in prices. Alternatively, for 18 of the years when prices rose seasonally, the price range increased in 16, decreased in 1, and remained unchanged during the other. For the 7 years when prices declined seasonally, there was a tendency for the price range to remain unchanged throughout the season. In 5 years, the price level remained unchanged and the price range increased during 4 of these years. In general, then, there was a definite tendency for the price range to increase seasonally whenever the level of prices was increasing. This same general pattern seemed to hold independent of the level of the early season price and independent of the time period considered.

Price Ranges Among Time Periods

The previous sections considered the long run pattern of price ranges in a general way. In this section more specific comparisons are made involving averages among the three time periods.

Average Price Ranges

Average monthly price ranges are shown in table 16 and figure 16. Because 1931 was so different from all of the other years under consideration (see figs. 13-15).

Table 15.—Relation between change in price level and change in price range, Michigan f.o.b. cash onion prices, 1930-68

Price level	Price range: Increase	Decrease	Unchanged
	Number of years		
Increase	16	1	1
Decrease	2	0	5
Unchanged	4	1	0

Table 16.—Average monthly price range, Michigan f.o.b. cash onion prices, September to March, selected periods, 1930-68

Month	Period Ia[1]	Period I[2]	Period II[3]	Period III[4]
	Dollars per 50-pound sack			
September	0.186	0.186	0.101	0.134
October	.162	.175	.128	.119
November	.183	.189	.146	.114
December	.158	.240	.173	.120
January	.223	.241	.265	.328
February	.445	.452	.341	.264
March	.489	.652	.260	.323

[1] 1930-1940; 1931 omitted.
[2] 1930-1940; no futures market.
[3] 1949-1957; active futures market.
[4] 1959-1968; no futures market.

two sets of figures are shown for period I; one is based on all years in the period and the other (period Ia) omits 1931. As expected, based on the previous sections, the range in all periods tended to rise as the marketing season progressed.

However, there are some differences among the periods. With the exception of January, the price range for every month during period I was larger than for the other two periods. In addition, the seasonal rise from September to March was substantially larger in period I than in the other two periods: the average increase was 0.466 in period I compared with 0.159 in period II and 0.189 in period III. Thus, there was considerably more within-month price variation during the first period than during either of the other two periods. However, much of the apparent difference when period I is compared with periods II and III is due to the influence of 1931. For period Ia, calculated by omitting 1931, the differences in the monthly price ranges are not so marked. In December, for example, the range averaged less in period Ia than in period II and only slightly larger than period III. Also, the difference for March is much less for period Ia than period I.

The case for period II versus period III is not as clearcut. For October, November, December, and February, the within-month price variation was less in period III than in period II. In addition, there were slight differences in the specific form of the seasonal pattern. Whereas in period I the greatest within-month price variation occurred in March, in period II it occurred in February and in period III in January, although for this period the range in March was, for all practical purposes, of equal magnitude. Overall, the degree of within-month price variation is about the same in periods II and III, given the slight alteration in the seasonal pattern.

Variation of Actual Price Ranges Around Average Price Ranges

The previous section involved comparisons of average price ranges, where these averages were calculated on the basis of the number of years in each period. As a result of this averaging process, considerable information is suppressed; specifically, the extent to which the actual price ranges varied around their respective averages. This degree of around-the-average variation may be measured by a statistic called the standard deviation which possesses the property that approximately 68 percent of the actual values will fall within a range defined by the average price range plus or minus one standard deviation unit. Thus, it provides an absolute measure of the extent of the variation of individual values around the average value—the larger the standard deviation, the greater the variation. Some caution must be exercised, however, when comparing the standard deviations for two different series, such as the price ranges for two different time periods, because the numerical value of the standard deviation is not independent of the measurement scale. To permit the making of such comparisons, a statistic known as the coefficient of variation may be calculated. This is accomplished by expressing the standard deviation as a percentage of the average value and this permits one to compare directly the *relative* variation of two different series. Both the standard deviations and the coefficients of variation of the average monthly price ranges shown in

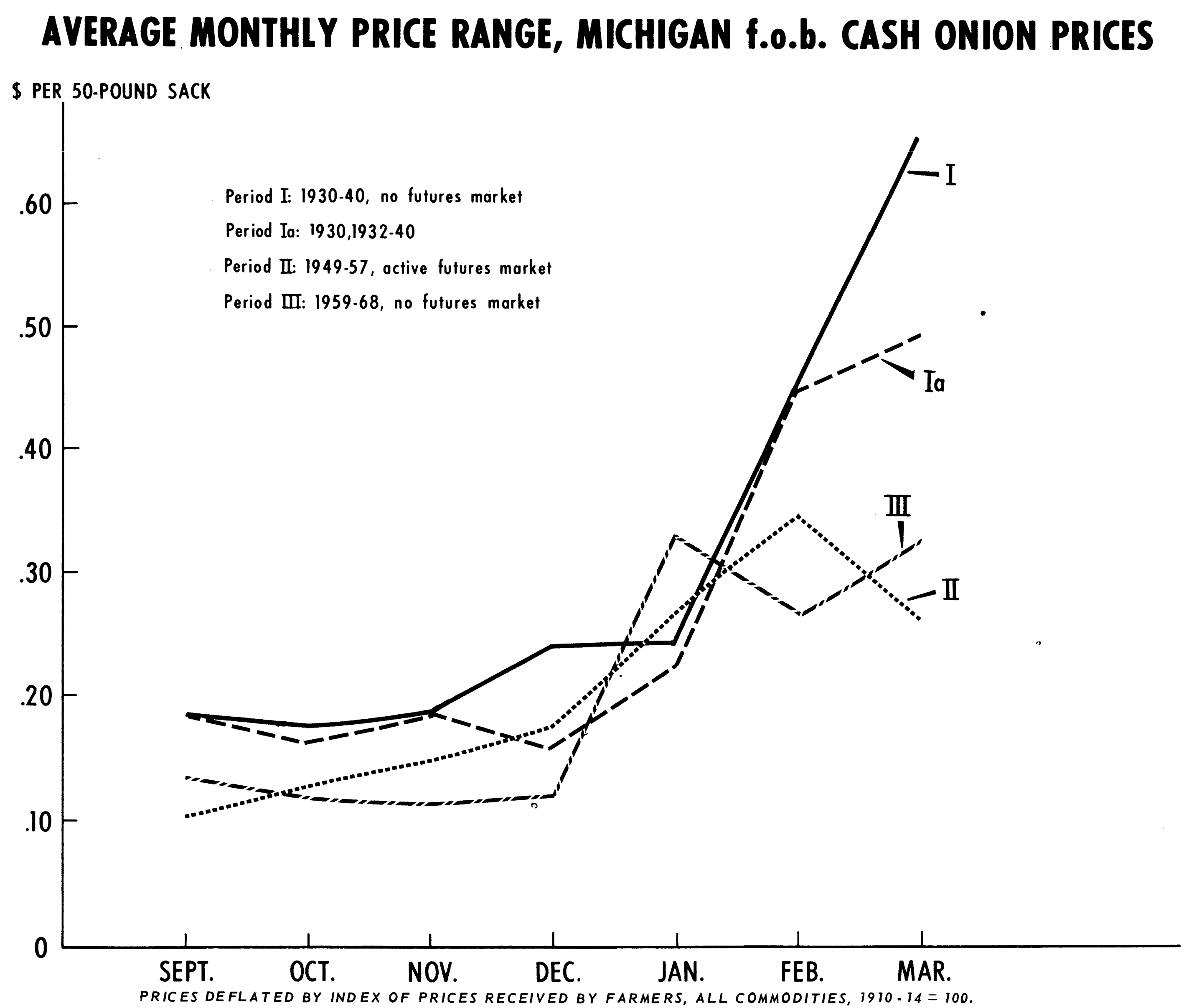

AVERAGE MONTHLY PRICE RANGE, MICHIGAN f.o.b. CASH ONION PRICES
$ PER 50-POUND SACK
Period I: 1930-40, no futures market
Period Ia: 1930,1932-40
Period II: 1949-57, active futures market
Period III: 1959-68, no futures market
.60
.50
.40
.30
.20
.10
0
I
Ia
III
II
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
PRICES DEFLATED BY INDEX OF PRICES RECEIVED BY FARMERS, ALL COMMODITIES, 1910-14 = 100.

Figure 16

the previous section are presented below. In evaluating them it must be kept in mind that one is an absolute measure of variation and the other is a relative measure.

Standard Deviations of Price Ranges. The standard deviations are presented in table 17 and figure 17. During the first 3 months of the marketing season, the standard deviation of the monthly price ranges was approximately the same in all three periods, although in period I it was consistently larger than in either of the other two periods. In December, the period I standard deviation was considerably larger than in the other two periods and the difference continued to increase throughout the remainder of the season, January being the only exception. The difference is particularly marked in March when the period I standard deviation was $0.566 per 50-pound sack compared with $0.089 and $0.187 in periods II and III, respectively. It is clear that considerably more variation in the monthly price range occurred in period I than in either periods II or III. However, as above, much of the disparity between period I and periods II and III is due to the extreme situation occurring in 1931. With this year omitted from the calculations, the standard deviations for September through January are essentially the same, suggesting little change in the variation of the price range over time. For February and March, variation was still greater in the first period; however, the difference is much less, especially for March, when 1931 is omitted.

Two points are obvious in the comparison of periods II and III. First, the standard deviation on a month-to-month basis was about the same for the two periods. The largest difference occurred in March when the difference was approximately $0.10 per 50-pound sack. Second, there is a smaller seasonal pattern for these two periods than is true for period I. During the first 4 months of the season, variation was remarkably stable in both periods, ranging approximately between $0.05 and $0.09 per 50-pound sack. For the remaining months, stability in variation was again in evidence, although in a range about $0.10 higher than during the early months.

Coefficients of Variation of Price Ranges. The coefficients of variation are presented in table 18 and figure 18. The same general relationships observed in the previous section are obvious here. Overall, relative variation appears to be greater for period I than for the other two periods, while for these latter periods the results are comparable, with the notable exception of September. As was true for the absolute variation, there is a definite tendency for relative variation to increase as the marketing season progresses.

Significance Tests

Considerable differences in average price ranges and in the variation of actual price ranges around their respective averages has been observed in the previous section. This raises the question of whether these differences are, in some sense, significant or if they simply occurred as a result of random, or chance, fluctuation. In other words, suppose that by some fortuitous circumstance one were to obtain a new set of price range data for the time period under consideration and used it to calculate averages and standard deviations as has been done here. What is the

Table 17.—Standard deviation of monthly price range, Michigan f.o.b. cash onion prices, September to March, selected periods, 1930-68

Month	Period Ia[1]	Period I[2]	Period II[3]	Period III[4]
	Dollars per 50-pound sack			
September	0.075	0.075	0.072	0.035
October	.085	.091	.065	.047
November	.106	.103	.040	.039
December	.054	.262	.092	.042
January	.124	.131	.142	.215
February	.310	.296	.182	.118
March	.242	.566	.089	.187

[1] 1930-40; 1931 omitted.
[2] 1930-40; no futures market.
[3] 1949-57; active futures market.
[4] 1959-68; no futures market.

STANDARD DEVIATION OF MONTHLY PRICE RANGE, MICHIGAN f.o.b. CASH ONION PRICES

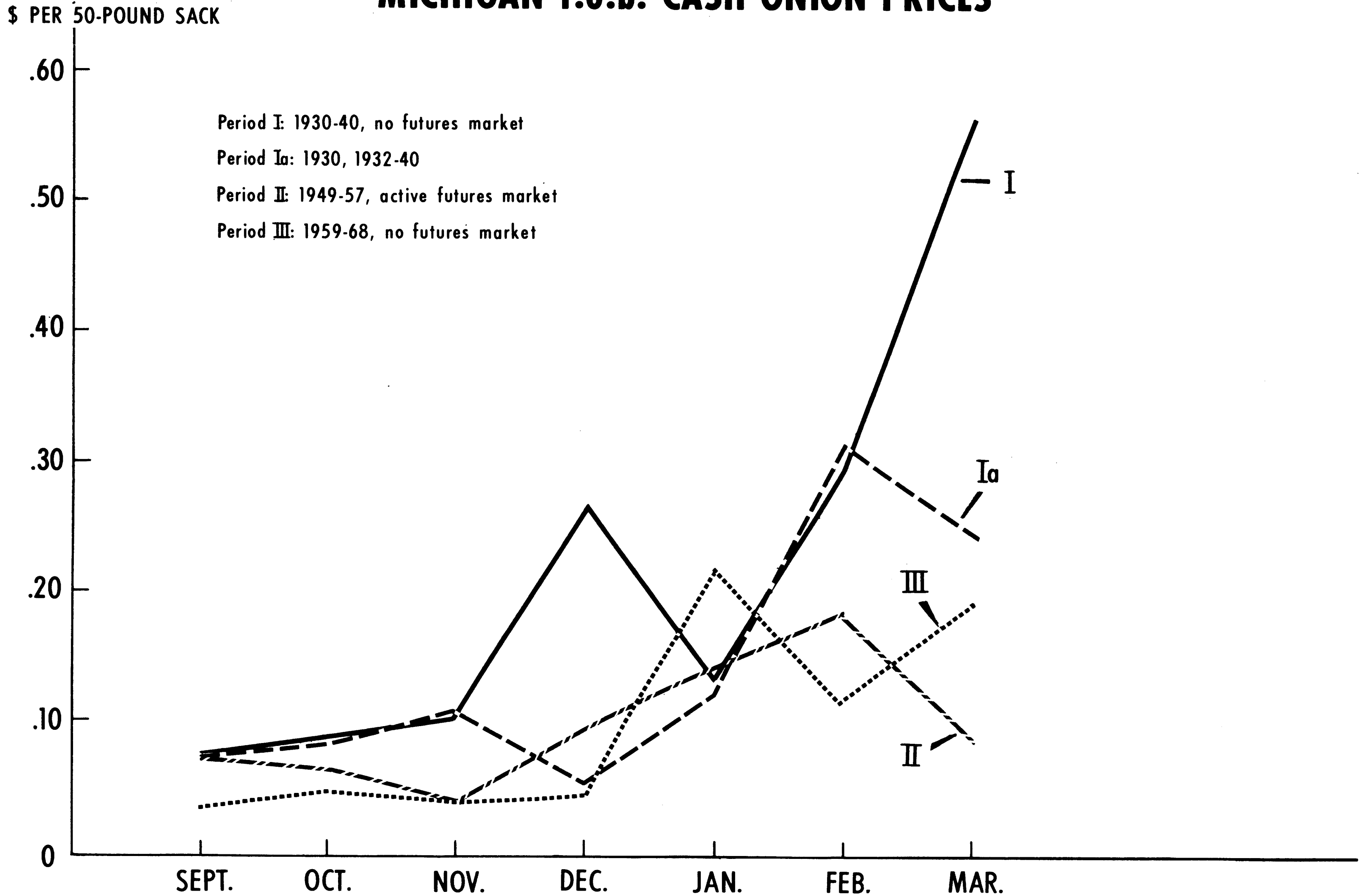


Figure 17

Table 18.—Coefficient of variation of monthly price range, Michigan f.o.b. cash onion prices, September to March, selected periods, 1930-68

Month	Period Ia[1]	Period I[2]	Period II[3]	Period III[4]
	Percent of average range			
September	40.4	40.4	72.0	26.1
October	52.5	52.0	50.8	39.5
November	58.0	54.5	27.4	34.2
December	34.2	109.0	53.2	35.0
January	55.6	54.4	53.6	65.6
February	69.6	65.5	53.4	44.7
March	49.5	86.7	34.3	57.9

[1] 1930-40; 1931 omitted.
[2] 1930-40; no futures market.
[3] 1949-57; active futures market.
[4] 1959-68; no futures market.

likelihood, or probability, that differences as large as those obtained here would be observed in this new set of data? At least a partial answer to this question may be obtained by using what is known as a t-test. The underlying theory of this test need not be of concern here, only that by its use one is able to make conditional statements concerning the probability that the differences observed in the average price ranges and in the standard deviations are due to something other than chance; that is, that the differences are significantly different.

The first step in using this test is to determine if the variances[34] of the price ranges for the various time periods are significantly different. If they are not different, then the t-test is directly applicable; if they are, then an approximation must be used which, in effect, results in a loss of degrees of freedom. However, since we are using this test as a descriptive device to assist us in interpreting the results we have obtained rather than as a means of rigorous hypothesis testing, these statistical complexities need not deter us.

The average monthly price ranges and their respective variances are presented in table 19. The first question of interest is whether the observed differences between the variances are significantly different. Table 20 shows the results of testing these variances. The symbol NS means that the probability is 0.95 that the variances are not statistically different; S means that the probability is 0.95 that the observed variances are statistically different. Two columns are shown for period I; one based on all the years and the other with 1931 omitted.

Variation in the price range during September, October, January, and February is not different between period I and period II, whether or not 1931 was included in the calculations. In November, the variance was significantly larger in period I. For December and March, however, different conclusions are drawn depending on whether 1931 is included. For December, the difference was not significant if 1931 is omitted but significant if it is included. The opposite is the case for March.

The variation in September, October, November, and February was significantly greater during period I than during period III, whether or not 1931 is included. It was not significantly different in January. For December and March, if 1931 is omitted, the difference is not significant; if it is included, the variation for these 2 months was significantly larger in period I than in period III.

Finally, the variation between periods II and III was not significantly different for October, November, January, and February. The variation in period II was significantly greater in September and December and significantly lower in March.

Using the averages and variances shown in table 19, the observed differences among periods between the average monthly price ranges for the same months were tested. In no case was the observed difference statistically different at the 0.95 level of probability. In other words, while there are some marked differences in the average price range for the same months among the periods, the probability is quite high that these observed differences are due to chance

[34] The variance is the square of the standard deviation.

COEFFICIENTS OF VARIATION OF MONTHLY PRICE RANGE, MICHIGAN f.o.b. CASH ONION PRICES

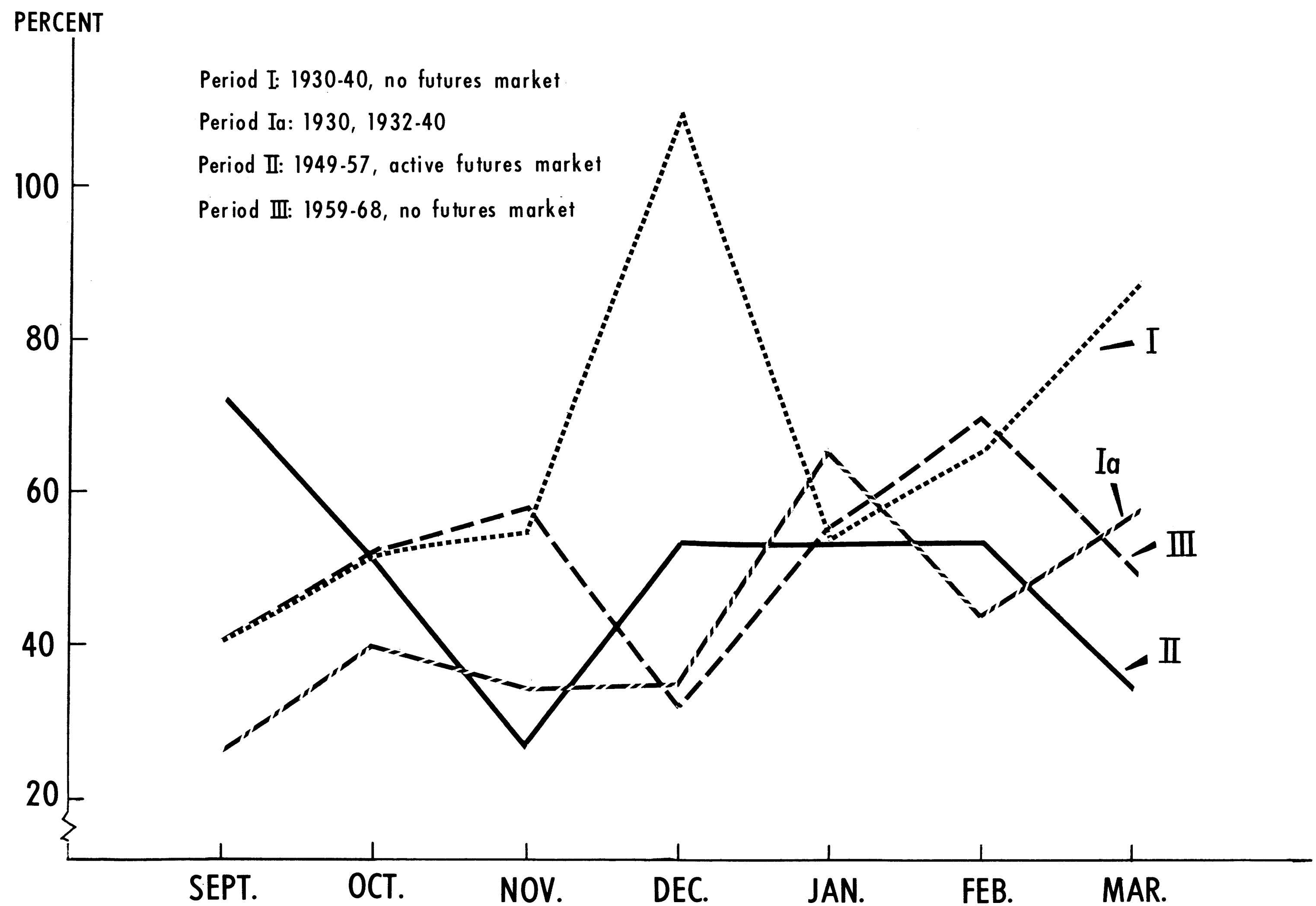


Figure 18

Table 19.—Averages and variances of monthly price ranges, Michigan f.o.b. cash onion prices, September to March, selected periods, 1930-68

Month	Average				Variance			
	Ia	I	II	III	Ia	I	II	III
September	0.186	0.186	0.101	0.134	0.0057	0.0057	0.0052	0.0012
October	.162	.175	.128	.119	.0073	.0083	.0043	.0022
November	.183	.189	.146	.114	.0112	.0106	.0016	.0015
December	.158	.240	.173	.120	.0029	.0688	.0085	.0018
January	.223	.241	.265	.328	.0154	.0173	.0201	.0460
February	.445	.452	.341	.264	.0964	.0878	.0332	.0140
March	.489	.652	.260	.323	.0586	.3202	.0080	.0351

Table 20.—Statistical tests of significance of variance ratios for monthly price ranges, Michigan f.o.b. cash onion prices, September to March, selected periods, 1930-68

Month	Periods Ia, II	Periods I, II	Periods Ia, III	Periods I, III	Periods II, III
September	NS	NS	S	S	S
October	NS	NS	S	S	NS
November	S	S	S	S	NS
December	NS	S	NS	S	S
January	NS	NS	NS	NS	NS
February	NS	NS	S	S	NS
March	S	NS	NS	S	S

S = Significantly different at 0.95 level of probability.
NS = Not significantly different at 0.95 level of probability.

alone, given the degree of variation which existed. The reason for this surprising result may be seen in figure 19, which shows for each month in each period the average price range (cross-mark) and the interval within which approximately 68 percent of the actual price ranges for that month would be expected to fall. The reason for the conclusion that the observed differences in the average price ranges are not significantly different is clear. Although the average price ranges differ substantially, the variation of the actual ranges about these averages has been sufficiently great as to preclude drawing the conclusion that the averages are different.

Distribution of Monthly Price Ranges

While averages and variances may not differ among the years, it is possible that the frequency with which large or small values occur may vary. Thus, an additional and final characteristic of the price ranges to consider is the frequency with which large and small ranges occurred among the three time periods.

Overall Distribution

The frequency distributions of the monthly price ranges, independent of the month in which they occurred, are shown in table 21. While precise conclusions cannot be drawn, it is clear that the distribution for period I, whether 1931 is or is not included, is generally different from the distribution for either period II or period III. These two periods for all practical purposes coincide, with the exception of the 0.21-0.30 category. In general, smaller values of the range occurred with less frequency in period I. For example, almost 63 percent and slightly over 71 percent of the price ranges in periods II and III, respectively, were $0.20 or less per 50-pound sack, while about one-half the ranges were this small in period I. Conversely, only 6 percent of the ranges in

AVERAGE MONTHLY PRICE RANGE AND INTERVAL THAT INCLUDES 68 PERCENT OF ACTUAL PRICE RANGES, MICHIGAN f.o.b. CASH ONION PRICES

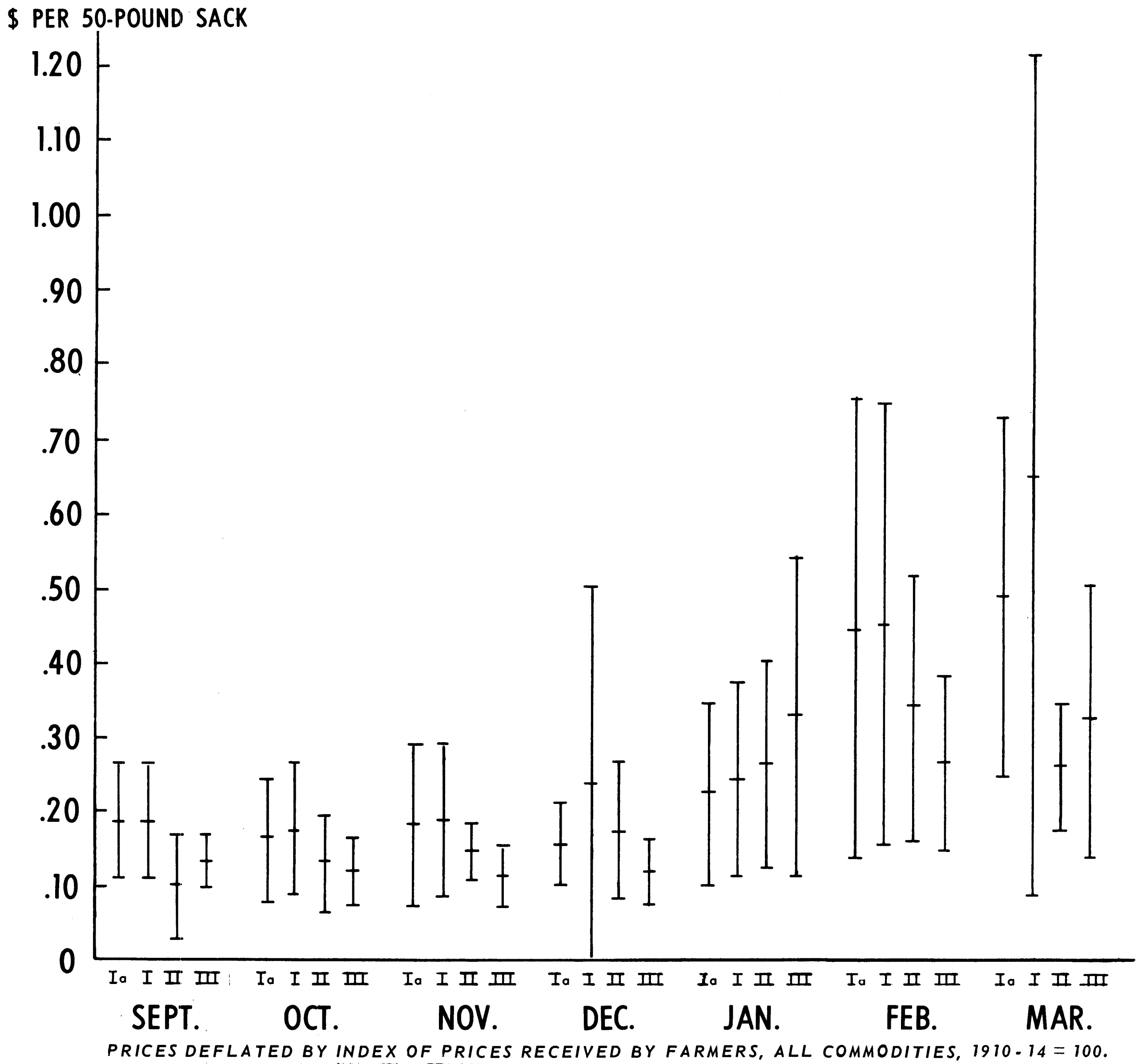


Figure 19

period II and 3 percent in period III exceeded $0.50 per 50-pound sack while slightly over 11 percent (8 percent with 1931 excluded) were of this magnitude in period I. In the extreme, 4.2 percent (1.5 percent with 1931 excluded) of the ranges in period I exceeded $1 per 50-pound sack—no ranges of this magnitude were observed in either period II or period III.

Early Versus Late Season Price Range

These frequency distributions do not recognize the presence of a seasonal pattern in the price range. In table 22, the frequency distributions are shown for early season (September to November) and for late season (February to March). Here some marked differences are evident. During the early season, only 64 percent (89 percent with 1931 excluded) of the price ranges were $0.20 or less in period I, compared with 85 percent in period II and 100 percent in period III. At the high end of the distribution, 11 percent (11.5 percent with 1931 excluded) of the price ranges were in excess of $0.30 per 50-pound sack in period I while no price ranges of this magnitude occurred in either periods II or III.

A similar relationship existed for the late season. For period I, only 9 percent of the ranges were $0.20 or less per 50-pound sack compared with 33 percent for period II and 35 percent for period III. Conversely, 68 percent (65 percent with 1931 excluded) of the ranges in period I exceeded $0.30 per 50-pound sack compared with 33 percent and 40 percent in periods II and III, respectively. Using over $0.50 per 50-pound sack as a comparison point, almost 32 percent of the ranges in period I were of this magnitude compared with 17 percent in period II and 5 percent in period III.

In summary, there was a definite tendency for small ranges to occur with less frequency and large ranges to occur with a greater frequency in period I than in either periods II or III. This relationship exists whether considering the season overall or recognizing the seasonal patterns. Finally, the distribution for periods II and III, with minor exceptions, are the same.

Table 21.—Frequency distribution of monthly price ranges, Michigan f.o.b. cash onion prices, selected periods, 1930-68

Monthly price range per 50-pound sack	Period Ia[1]	Period I[2]	Period II[3]	Period III[4]
0-$0.10	0.182	0.167	0.161	0.200
$0.11-$0.20	.333	.305	.468	.512
$0.21-$0.30	.212	.222	.210	.100
$0.31-$0.40	.106	.097	.081	.100
$0.41-$0.50	.091	.097	.016	.058
over $0.50	.076	.112	.064	.030
	(1.000)	(1.000)	(1.000)	(1.000)
over $1.00	.015	.042	0	0

[1] 1930-40; 1931 omitted.
[2] 1930-40; no futures market.
[3] 1949-57; active futures market.
[4] 1959-68; no futures market.

Table 22.–Frequency distribution of monthly price ranges, Michigan f.o.b. cash onion prices, early and late season, selected periods, 1930-68

Season and monthly price range per 50-pound sack	Period Ia[1]	Period I[2]	Period II[3]	Period III[4]
Early season (Sept.-Nov.):				
0-$0.10	0.269	0.250	0.346	0.300
$0.11-$0.20	.423	.390	.500	.700
$0.21-$0.30	.193	.250	.154	0
$0.31-$0.40	.077	.073	0	0
$0.41-$0.50	.038	.037	0	0
$0.51-$0.60	0	0	0	0
$0.61-$0.70	0	0	0	0
over $0.70	0	0	0	0
	(1.000)	(1.00)	(1.00)	(1.00)
over $1.00	0	0	0	0
over $1.20	0	0	0	0
Late season (Feb.-Mar.):				
0-$0.10	.050	.045	0	0
$0.11-$0.20	.050	.045	.333	.350
$0.21-$0.30	.250	.227	.333	.250
$0.31-$0.40	.200	.182	.111	.250
$0.41-$0.50	.200	.182	.056	.100
$0.51-$0.60	.050	.092	.111	0
$0.61-$0.70	0	0	.056	0
over $0.70	.200	.227	0	.050
	(1.000)	(1.000)	(1.000)	(1.000)
over $1.00	.050	.090	0	0
over $1.20	0	.045	0	0

[1] 1930-40; 1931 omitted.
[2] 1930-40; no futures market.
[3] 1949-57; active futures market.
[4] 1959-68; no futures market.

CHAPTER 7. RANDOM VARIATION IN ONION PRICES

The analyses in chapters 4, 5, and 6 focused on the total variation in the price series being considered. In this chapter, an alternative procedure, which decomposes the total variance into two separate components of interest, is presented and applied to cash onion prices. The underlying model is presented in the following section. The next section proposes a method for estimation. The third section involves a brief discussion of the relationship between this model and the random walk theory, which is receiving considerable attention in the context of futures markets. The application of the model to Michigan f.o.b. cash onion prices by crop years is presented in the final section.

The Model

The movement of price over time is assumed to consist of two parts, or components—a systematic component and a random component. In the context of a commodity market, the systematic component is associated with changes in fundamental market supply and demand factors. An illustration of this is presented in chapters 4 and 5 where the theory of the perfectly competitive market in time is discussed. There is shown that under the stated assumptions price is expected to increase seasonally in relation to the cost of storage; such a price movement would be a systematic movement. Similarly, changes in the average price level from one crop season to the next in response to different supply conditions might be viewed as a systematic change. From the standpoint of price performance, such changes are necessary and desirable if the economic system is characterized by a free market wherein price has the function of allocating resources and distributing output.

The word "random," used to describe the other component of price movement, means that portion of price change which is nonsystematic in the sense that it cannot be predicted. Whether random variation is good or bad depends on the arguments one cares to make. For example, one could view random variation as "noise" in the pricing system which, because it provides no relevant information and is not a response to fundamental market conditions, should be eliminated. Consequently, when comparing two different periods, price performance would be viewed as more acceptable during the period when the price variation due to the random component was less. Alternatively, one could argue that price responds to changes in market conditions, such changes occur randomly over time, and consequently, price should vary randomly. In this case, all of the observed variation in price would be associated with the random component and price performance would be deemed acceptable.

Given these problems of interpretation, the model under consideration may be expressed in equation form as:

$$P_t = S_t + E_t$$

where P is the observed price at time t, S is the systematic component, and E is the random component. The variance of P over time is given by:

$$V(P_t) = V(S_t) + V(E_t)$$

where it is assumed that the correlation (covariance) between the systematic and random components is zero. This equation provides the desired decomposition of the total variation of price into the sum of two separate variances. The question of estimation must now be considered.

Variate Difference Analysis as Estimating Procedure

There may be several ways by which it would be possible to estimate the variance of the two components. For our purposes, the variate difference method will be used.[35] This method requires as a basic assumption that the time series to be investigated be decomposable into two separate components, one systematic and one random. This assumption is made above.

The second assumption required is that the systematic component of price be represented by, or at least approximated reasonably well by, a polynomial of degree *n* in time. This assumption permits use of the mathematical property of a polynomial of degree *n* that by successive differencing it is eliminated by the n + 1 finite difference.

Using these assumptions, the variate difference analysis proceeds as follows. First, the systematic

[35] See Tintner, G., *The Variate Difference Method,* Principia Press, Inc., Bloomington, Ind., 1940.

component is removed from the series by finite differencing. This differencing affects the systematic component only, since by definition the random component is not affected. Second, the variance of each successive difference is calculated. Third, a statistical test is applied between each consecutive pair of differences. When the variance does not change statistically with each higher order difference, it is assumed that the systematic component has been eliminated and the variance of the random component has been estimated. This occurs when the difference in variance for two successive differences is less than three times the standard error of the difference.

An illustration may be helpful. Suppose that the systematic component of price may be represented by a polynomial of degree 1 in time. Actual prices for any period may be expressed as:

$$
\begin{aligned}
P_t &= bt + E_t \\
P_{t-1} &= b(t-1) + E_{t-1} \\
P_{t-2} &= b(t-2) + E_{t-2} \\
&\vdots
\end{aligned}
$$

where the systematic component, S_t, has been written as the polynomial b_t. First differences are calculated by subtracting price in t-1 from price in t_1 so from the above we have:

$$
\begin{aligned}
P_t - P_{t-1} &= bt + E_t - bt + b - E_{t-1} = b + E_t - E_{t-1} \\
P_{t-1} - P_{t-2} &= bt - b + E_{t-1} - bt + 2b - E_{t-2} \\
&= b + E_{t-1} - E_{t-2} \\
&\vdots
\end{aligned}
$$

Observe that the coefficient b remains in the expressions for the first differences so the systematic component has not been removed. Since the second differences of the original series, $P_t, P_{t-1}, P_{t-2}, \ldots$, are actually first differences of the first differences shown above, we have:

$$
(P_t - P_{t-1}) - (P_{t-1} - P_{t-2}) = E_t - 2E_{t-1} + E_{t-2}
$$

$$\vdots$$

Note that the second differences consist only of random terms. In other words, the systematic component has been "differenced" out and only the random component remains. In the context of variate difference analysis, the estimate of the variance of the random component in this illustration would be given by the variance of the second difference. Of course, when using actual prices things do not fall out as neatly as above because it would not typically be possible to represent the systematic component by such a simple polynomial. Consequently, it is necessary to rely on the statistical test to determine when an estimate of the desired variance is obtained.

Relation to the Theory of Random Walk

The body of literature, both theoretical and empirical, relating to the theory of random walk is becoming rather extensive. It is not the intent here to either review this literature or to comment on its merits.[36] Further, no rigorous attempt will be made to relate this theory with the variate difference analysis. However, a relationship between the two exists and it will be sketched here.

Statistically, the theory of random walk says that commodity price changes over time are random; practically, it says that knowledge of today's price only is not sufficient to predict tomorrow's price. Symbolically it is

$$P_t = P_t + E_t$$

or

$$P_t - P_{t-1} = E_t$$

where P_t is price in the t-th period and E_t is a random component. The equation says that price in t is equal to price in t-1 plus a random value, or the change in price from t-1 to t is equal to a random value. Regardless of the way it is interpreted, the result is the same; namely, price in t-1 is not a good prediction of price in t.

The equation immediately above shows price change to consist of a random component only. In the

[36] For the most comprehensive treatment to date and for an excellent bibliography see Labys, W. S. and C. W. J. Granger, *Speculation, Hedging and Commodity Price Forecasting*, D. C. Heath and Co., Lexington, Mass., 1970.

context of variate difference analysis, where this price change is the first difference of price, the variance of the random component would be given by the variance of the original series, since the original series contains no systematic component. This relation suggests that variate difference analysis may be interpreted in terms of the random walk theory: If the variance of the first difference of the original series provides the estimate of the variance of the random component, then the original series contains no systematic component, which means that it follows a random walk; if a higher order difference is required to provide the estimate of the random component, then the original series has a systematic component and does not follow a random walk.

As discussed above, whether the presence of random variation in price implies desirable or undesirable price performance depends on one's point of view. Either position may be defended by alternative assumptions concerning how price is formed in competitive markets. The resolution of these differences must await further theoretical and empirical analyses.

Much of the literature on random walk is unclear as to whether cash prices or futures prices are being considered. Often the terms "speculative prices" or "speculative markets" are used but they are seldom made explicit. However, it appears that futures prices (or stock market prices) are used as the base. Little work has been done on the question of whether cash prices should also be expected to follow a random walk, although there is some empirical evidence to suggest that such is the case for some commodities.[37]

For some commodities, such as late summer onions, it seems reasonable to expect that price movement within a storage season might consist of both a systematic and a random component. The systematic could arise from the theory of the seasonal price pattern presented in chapters 4 and 5. The random component could arise from randomly generated changes in information during the storage-selling season—weather while the new crop of onions is being grown and harvested in Texas could be an extremely important source of random variation in price during the season. An attempt was made to approximate this type of variation by use of the within-month price range in chapter 6. If this is the case, then we would expect when using variate difference analysis that a high order difference would be required to provide the estimate of the variance of the random component because several differences would be required to remove the systematic component associated with "normal" seasonality.

[37] See the book by Labys and Granger cited above.

The Analysis

The results obtained from applying the variate difference analysis to Michigan f.o.b. cash onion prices on a year-to-year basis are presented and discussed in this section. Since interest centers on the impact of the futures market on price performance, the analysis centers on the periods prior to, during, and following futures trading in onions. Given all of the problems of interpretation discussed above, this discussion is descriptive—interpretation is left to the reader.

The variance of the weekly cash prices by crop years is shown in figure 20. The horizontal line drawn through each of the periods represents the simple average variance for each period. It is presented to facilitate visual comparisons and no other significance should be attached to it. The relationships shown here have been seen at many points in the main part of the text and need no further comment.

The estimates of the variance of the random component using variate difference analysis are shown in figure 21. Again the simple averages by time periods are shown to facilitate comparisons. It is clear that the variance of the random component in the cash onion price has been declining. Using the simple average as a crude index, the variance of the random component before futures trading was about 10 times as great as during the period of futures trading, and about four times as great during the period of futures trading as during the period following the ban on trading. Of course, in each period the simple averages are heavily influenced by one or two extreme observations. However, if these are ignored it is still clear that there has been a downward trend in the variance of the random component over time. In addition to this movement, there has been a tendency for the year-to-year changes in this variance to be smaller during each successive period.[38]

The information in figures 20 and 21 is summarized in figure 22 by expressing the variance of the random component as a percentage of the total variance. The calculation for 1932 is omitted as this was the only year over the total period for which the variance of the random component was equal to the total variance.

[38] These results are consistent with those presented in Chapter 6 concerning changes in the magnitude of the within-month price range.

VARIANCE OF ACTUAL WEEKLY MICHIGAN f.o.b. CASH ONION PRICES

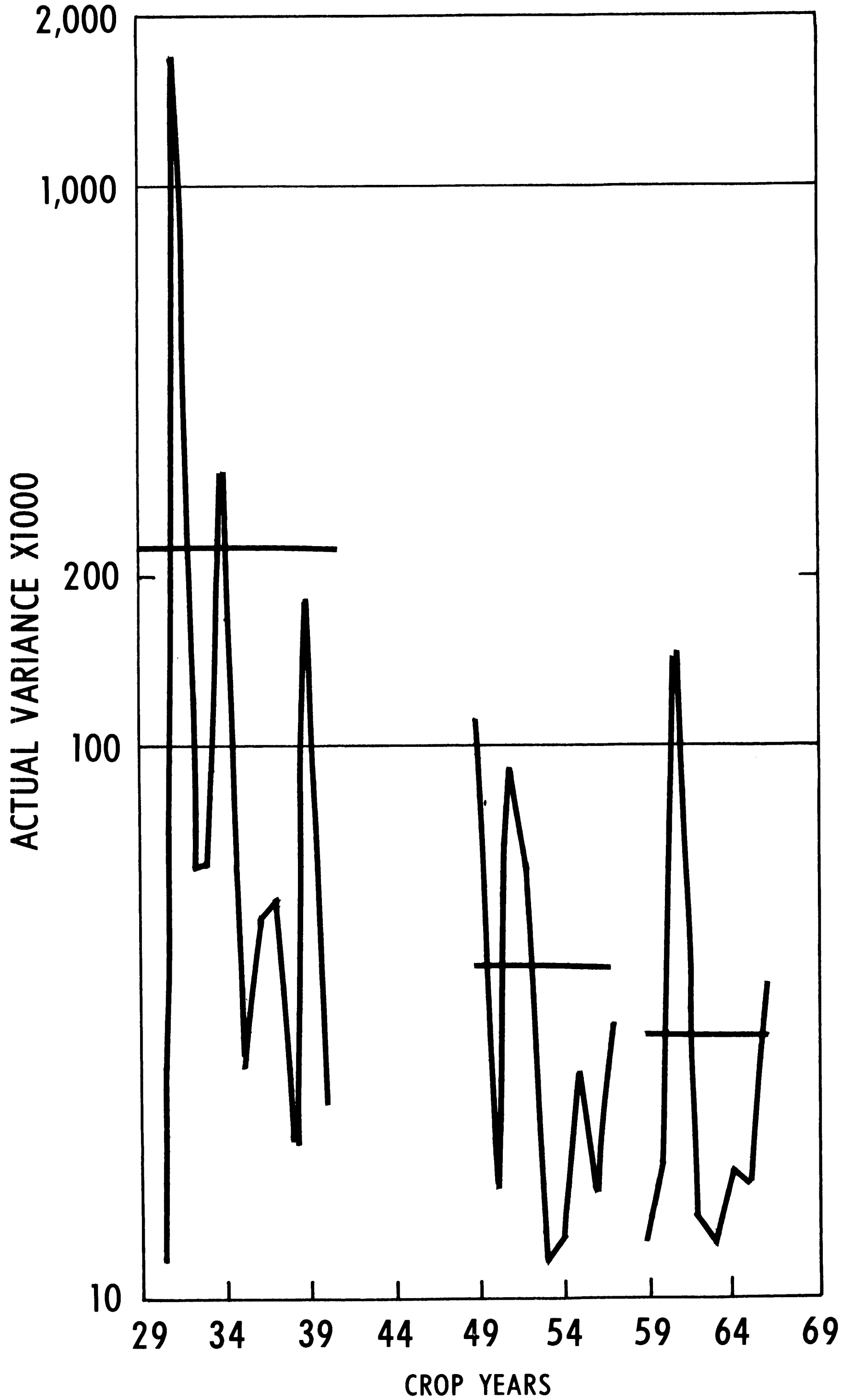


Figure 20

VARIANCE OF RANDOM COMPONENT OF WEEKLY MICHIGAN f.o.b. CASH ONION PRICES

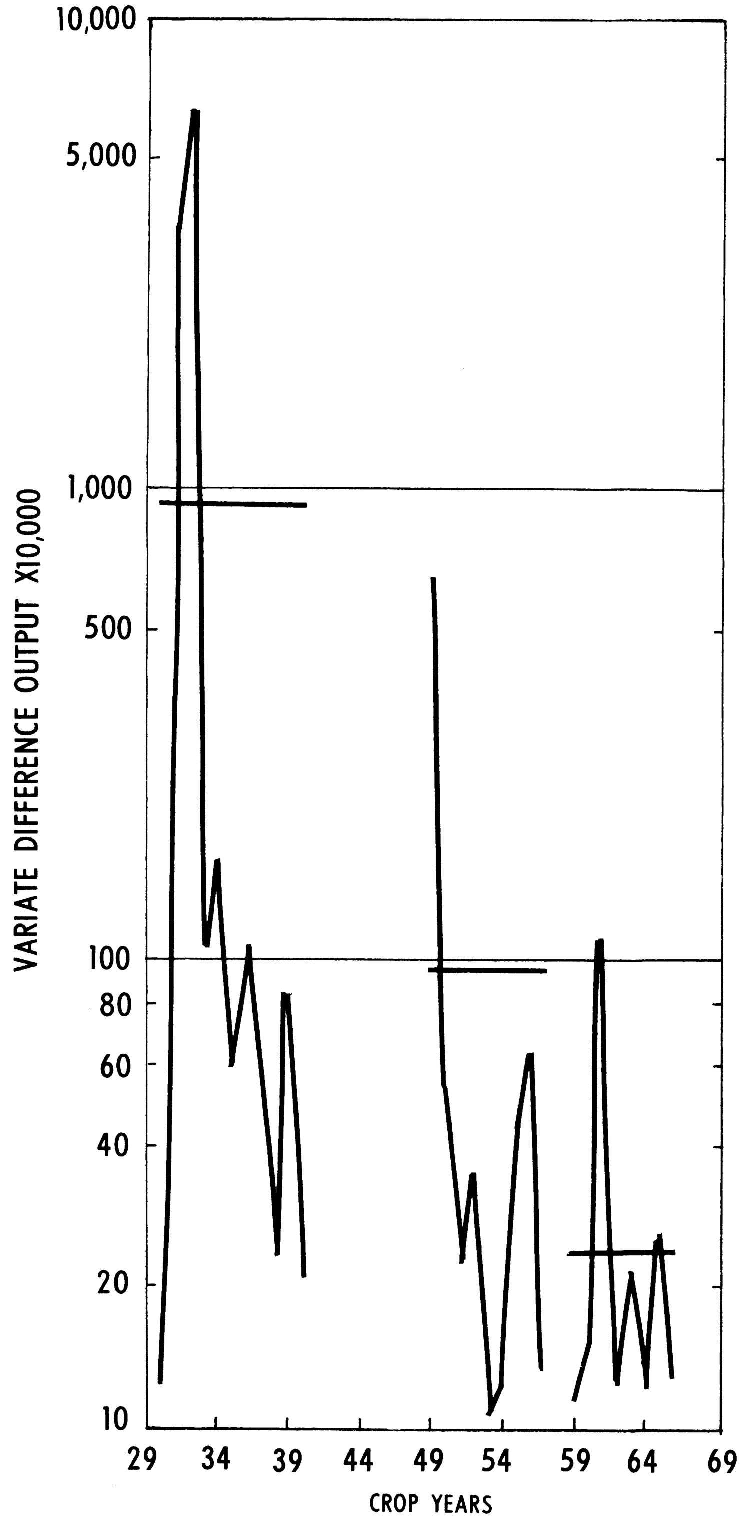


Figure 21

VARIANCE OF RANDOM COMPONENT AS PERCENT OF TOTAL VARIANCE, WEEKLY MICHIGAN f.o.b. CASH ONION PRICES

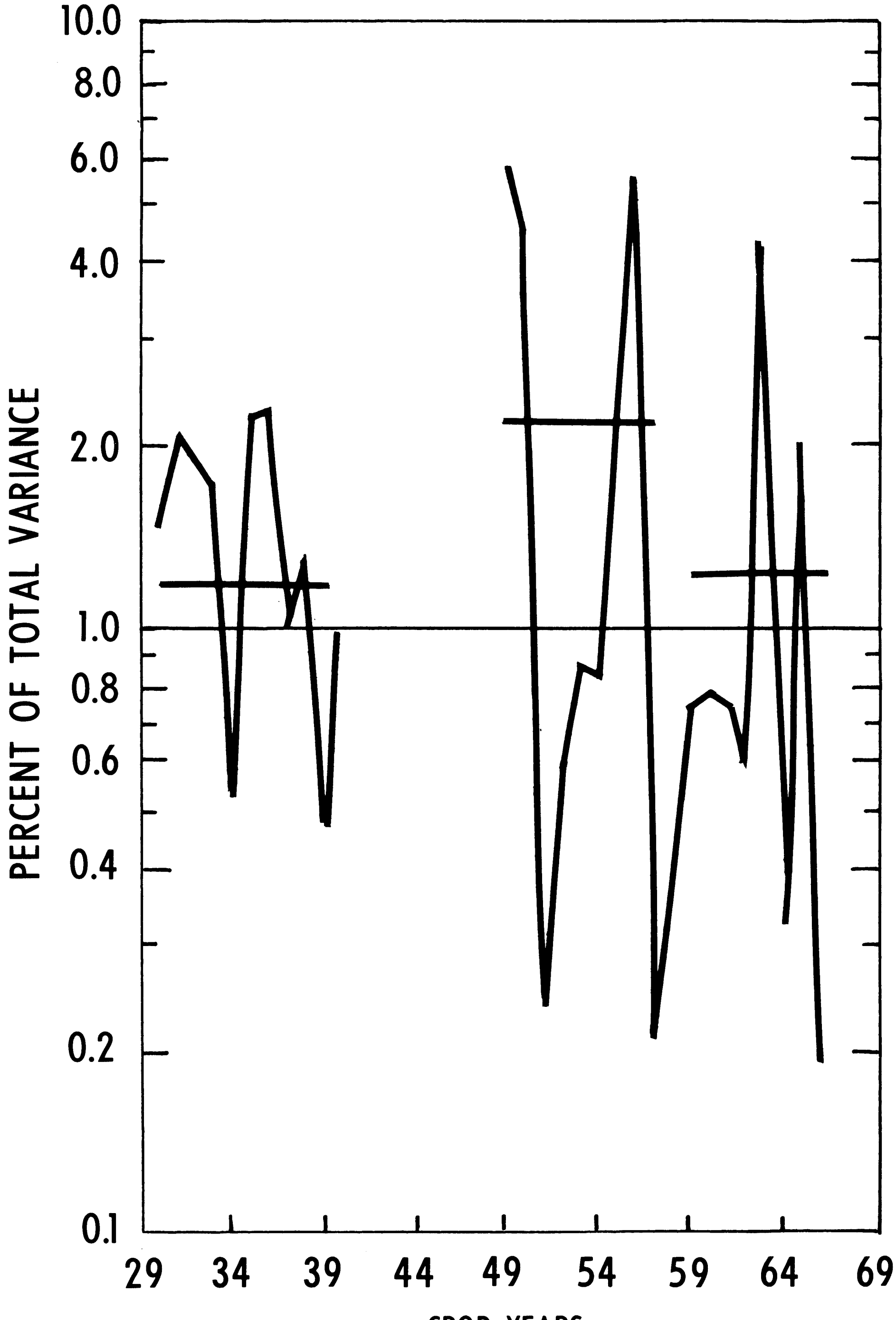


Figure 22

An interesting pattern is shown here, namely, on a relative basis the variance of the random component was about the same during the two periods of no futures trading and lower than during the period of the futures market. (Of course, in no case is the random variance a particularly high proportion of the total; it was about 6 percent in 2 years and over 4 percent in another.) What this pattern means with respect to the relative price performance among the three periods is not at all clear. If one argues that random movement should be eliminated because it interferes with the information provided by price change, then one could conclude that price performance was more acceptable during the periods of no futures trading. On the other hand, it could be argued with equal tenacity that, in a perfectly competitive market where price responds instantaneously to changing market conditions and where these conditions are changing randomly (e.g., a frost in Texas), price change over time should follow a random pattern. In this case, the conclusion could be that price performance was more acceptable during the period of substantial futures trading.

CHAPTER 8. PRICE PERFORMANCE OVER SPACE

Theoretical Framework

This chapter considers the performance of cash onion prices among markets separated by space. The evaluation is conducted within the framework of the "perfect market in space." Since this theory is well-developed elsewhere, it need not be repeated here.[39] It is sufficient for current purposes to draw from this theory the types of relationships expected to exist among observed prices if they have been determined under perfectly competitive conditions. Specifically, for a commodity such as onions, that is produced and sold at many different geographical locations within the United States, prices at all of these points should be interrelated through the cost of transportation from one point to another.

Further, if because of changes in market conditions price changes by a certain amount at a particular point in the market system, then prices at all other points will change by the same amount once the changes in market conditions have had time to work themselves out. For example, if the price for Michigan-grown onions in the Chicago wholesale market increases by $0.50 per sack, then the price for Michigan-grown onions at the shipping point in Michigan should also increase by $0.50 per sack if the market is operating under competitive conditions. Similarily, if the Michigan f.o.b. price declines by $0.25 per sack, then the New York f.o.b. price will decline by an equal amount.

However, several factors may cause the actual price relations to differ from theoretical expectations. For example, there may be a lag in information flow so that, when price in one market changes, time may be required before the commodity flow can be redirected to bring about the requisite change of price in another market. The quality of onions associated with prices in different markets may differ so that the onions flowing among markets may not be perfect substitutes. Or, because of advertising, consumers may prefer onions from one producing region as opposed to another, even though in terms of physical characteristics the commodities may be the same. In either event, price in one market will change within some small range without causing a change of price in the other market. If onion shippers have acquired the habit of shipping to one market or have developed business arrangements with buyers in a particular market on which they place considerable value, then they will be reluctant to alter their shipment pattern to other markets even though prices may be somewhat higher. In a similar vein, shippers may not expect the higher price to persist so they become reluctant to change markets. There may be other reasons that result in deviations of actual price relations from theoretical relations.

[39] See Bressler, R. G. and R. A. King, ***Markets, Prices, and Interregional Trade,*** John Wiley & Sons, Inc., 1970, especially part II.

The Research Approach

The empirical investigation of the performance of onion prices among markets separated by space utilizes a technique called regression analysis. To develop an understanding of how to interpret the results obtained from regression analysis, it is necessary to detour briefly. Relevant considerations are developed in the sections that immediately follow. The regression results are presented and discussed in the following section.

Use of Regression Equation for Assessing Price Performance

The theory of the competitive market over space sketched above shows that prices in spatially separated markets are so related that, if price in one region changes, there will be equal and like changes in all markets. Thus, on theoretical grounds, if two price series were compared—say, the Michigan f.o.b. shipping point and the Chicago wholesale onion prices—by plotting them on graph paper, they should follow exactly the same path over time. However, the time paths would not coincide because the theory says that prices in separate markets will differ by an amount equal to the transportation cost between them. Since the flow of onions is typically from the producing region in Michigan to the consuming region in Chicago, the price in Chicago should be higher than the price in Michigan by the cost of shipping onions from Michigan to Chicago.

A formal and general statement of this situation is given by the following equation:

$$P_1 = a + bP_2$$

when P_i represents the price in the i-th market. The "a" in this equation is the constant term. In the context of the theory, it represents the fixed cost of transportation between markets 1 and 2. The "b" is the regression slope that shows the amount by which P_1, the dependent variable, changes when P_2, the independent variable, changes by one unit. In the theory of the perfectly competitive market in space, the numerical value of b should be 1.0–if the price for Michigan-grown onions in Chicago increases (decreases) by $0.25 per sack, then the price at the shipping point in Michigan will increase (decrease) by $0.25 per sack. A formulation of this type will be employed in subsequent sections to evaluate the performance of onion prices in markets separated by space.

Sampling Variability and Probability Statements

When a set of data, such as a price series, is used to estimate the parameters of a regression equation (the "a" and "b" in the equation of the previous section), the actual numerical values obtained will depend upon the particular set of data used. In other words, if a slightly different set of data pertaining to the same "population," e.g., the Michigan f.o.b. price, had been used, then different numerical values would have been obtained for the estimates. Thus, to use the available price series to estimate the regression coefficients it is necessary to view these prices as a sample drawn from some underlying population. This introduces the idea of sampling variability which provides a basis for explaining the fact that different numerical values are likely to be obtained from different samples. But recognition of sampling variability also permits us to draw upon sampling theory to make probability statements concerning the relationship between the numerical results obtained and the results expected.

For example, in evaluating price performance over space we expect to obtain a "b" equal to 1.00 if the market is operating under perfectly competitive conditions. Suppose that a particular set of data yields a value of 0.96. The relevant question is whether this difference (0.96 vs. 1.00) could have arisen simply because of chance, i.e., because of sampling variability. It is not possible to answer this question unequivocally but it is possible to make probability statements. We can, for example, say that we are 95 percent sure, or that the odds are 95 out of 100, that this difference is due to sampling variability. In other words, we can be reasonably sure that the true "b" is equal to 1.00 even though a value of 0.96 was obtained.

To account for this possibility of sampling variability, the statistical information provided by the regression analysis is used to calculate an interval–a low value and a high value–in such a way that we can state the probability that the true regression slope falls within that interval. Such an interval is called a confidence interval; a 95 percent confidence interval would specify the interval, or range of values, for which the odds are 95 out of 100 that the true regression slope is included. Consequently, if the regression slope of interest (in this case a slope of 1.00) is not included in the interval, then the odds are high that the true slope is not equal to 1.00. The degree of confidence, or the probability interval, to use in making such judgments is, to a large extent, a matter of personal preference. It is customary in empirical research to use either the 95 percent or 99 percent confidence interval; consequently, in most of the tables that follow, both intervals are presented. The textual discussion of the results will be based on the 95 percent confidence interval. However, there are a number of cases where the conclusions concerning the performance of the market, relative to the competitive norm, are different depending on which confidence interval is used.

Estimated Regressions and Extent of Data Pooling

In assessing the price performance of the onion market, several alternative formulations have been developed that vary according to the specific markets compared and the degree of data pooling.[40] The first involves regressions for seven different market comparisons. In some cases, the comparisons involve shipping point–wholesale prices for onions grown in a particular producing region. Others involve prices for onions grown in different producing regions but priced at the same level of the marketing system, such as f.o.b. shipping point or wholesale. These equations are estimated using weekly prices with all years in 1930-67 pooled into one data set. The second set of equations involves the same market comparisons but the data are pooled into groups of years rather than over the entire period. The specific groups of years are 1930-40, 1949-57, and 1959-67. The third set of equations involves two-market comparison; Michigan f.o.b. shipping point with Michigan wholesale price at Chicago, and Michigan f.o.b. shipping point with New York f.o.b. shipping point. For these comparisons, equations are estimated for each individual year for the entire period.

[40] The question of causal direction is considered in chapter 9.

The reason for this progressive disaggregation in terms of number of years pooled is to assess the extent to which conclusions concerning price performance would be altered by the degree of pooling used in estimating the equations. It is possible, for example, that when all the years are pooled the estimated regression slope is equal to 1.00; but it could be that the slope was actually greater than 1.00 for one period and less than 1.00 for a different period. Consequently, the result obtained reflects an averaging process and is not a good indication of how the market actually performed. A final section of this chapter presents an attempt to determine to what extent lags occur in the market.

Regression Results

All Years

The regression results for the seven market comparisons based on all years in 1930-67 are presented in table 23. The results relative to the competitive norm are mixed. For four of the comparisons—Michigan f.o.b. and Chicago wholesale; New York f.o.b. and New York wholesale; Michigan, Chicago and New York wholesale; and Texas f.o.b. and New York wholesale—the confidence interval does not include the value of 1.00, which indicates that these markets did not perform in accordance with the competitive norm. For the first two comparisons, the slope is greater than 1.00 and for the latter two comparisons it is less than 1.00. For the other three market comparisons, the results conformed to expectations.

Groups of Years

Regression results based on groups of years are presented in table 24. For five of the comparisons shown, a definite pattern emerges; namely, prices performed in accordance with the competitive norm during 1949-57 but failed to do so in the other two periods. For the Michigan f.o.b.—wholesale comparison, the regression slope exceeded a value of 1.00 in each of these two periods. For the other four market comparisons, the regression slope was greater than 1.00 for 1930-40, equal to 1.00 for 1949-57, and less than 1.00 for 1959-67. In addition to the tendency for the slope to decrease in magnitude in successive time periods, the correlation coefficient, R^2, consistently declined.[41] Thus, not only was there a tendency for

[41] The correlation coefficient, R^2, is a calculated statistic which expresses the percentage of the variation in one variable that is associated with variation in another variable. Its numerical value is restricted to the 0-1.00 range. If perfectly competitive conditions exist among markets separated by space, then the correlation coefficient should be equal to 1.00.

Table 23.—Onion prices: Regression results, dependent variable on left, various marketing points, based on weekly prices, 1930-67

Price relationship	Estimated regression slope	Confidence interval		Interval includes value of 1.00		R^2
		95 percent	99 percent	95 percent	99 percent	
Michigan f.o.b.: Michigan, Chicago wholesale	1.05	1.03-1.06	1.02-1.07	No	No	0.95
Michigan f.o.b.: Michigan, New York City Wholesale	1.02	1.00-1.03	.99-1.04	Yes	Yes	.95
Michigan f.o.b.: New York f.o.b.	1.00	.99-1.01	.99-1.02	Yes	Yes	.98
New York f.o.b.: New York, New York City wholesale	1.02	1.01-1.03	1.00-1.04	No	Yes	.96
Michigan, New York City wholesale: New York, New York City wholesale	1.01	1.00-1.03	.99-1.04	Yes	Yes	.96
Michigan, Chicago wholesale: Michigan, New York City wholesale	.94	.92- .96	.91- .97	No	No	.92
Texas f.o.b.: Texas, New York City wholesale	.68	.64- .71	.62- .73	No	No	.87

Table 24.–Onion prices: Regression results, dependent variable on left, various marketing points, based on weekly prices, selected periods, 1930-67

Price relationship and period	Estimated regression slope	Confidence interval		Interval includes value of 1.00		R^2
		95 percent	99 percent	95 percent	99 percent	
Mich. f.o.b.: Mich., Chi. whlse.						
1930-40	1.05	1.02-1.07	1.01-1.08	No	No	0.97
1949-57	1.02	.98-1.05	.97-1.07	Yes	Yes	.94
1959-67	1.05	1.01-1.08	.99-1.10	No	Yes	.93
Mich. f.o.b.: Mich., New York City whlse.						
1930-40	1.07	1.04-1.09	1.03-1.11	No	No	.97
1949-57	.99	.96-1.02	.94-1.04	Yes	Yes	.95
1959-67	.90	.83- .97	.79-1.01	No	Yes	.80
Mich. f.o.b.: New York f.o.b.						
1930-40	1.02	1.01-1.03	1.00-1.04	No	No	.99
1949-57	.94	.92- .97	.91- .98	No	No	.97
1959-67	.94	.92- .97	.91- .98	No	No	.97
New York f.o.b.: New York, New York City whlse.						
1930-40	1.06	1.05-1.07	1.04-1.09	No	No	.98
1949-57	1.02	.99-1.05	.97-1.06	Yes	Yes	.96
1959-67	.89	.85- .93	.83- .95	No	No	.88
Mich., New York City whlse.: New York, New York City whlse.						
1930-40	1.04	1.02-1.06	1.01-1.07	No	No	.98
1949-57	.97	.93-1.00	.92-1.00	Yes	Yes	.94
1959-67	.85	.79- .92	.75- .96	No	No	.80
Mich., Chi. whlse.: Mich., New York City, whlse.						
1930-40	1.00	.97-1.03	.96-1.04	Yes	Yes	.95
1949-57	.93	.88- .98	.86-1.00	No	Yes	.89
1959-67	.83	.77- .89	.74- .93	No	No	.82
Texas f.o.b.: Texas, New York City, whlse.						
1930-40	.70	.63- .77	.60- .80	No	No	.91
1949-57	.95	.86-1.05	.81-1.09	Yes	Yes	.86
1959-67	.83	.75- .90	.72- .93	No	No	.88

performance to diverge from the competitive norm but the degree to which the prices in the respective markets moved together declined over time.

Although the correlation coefficient for the Michigan–New York f.o.b. comparison is very high, the regression coefficient exceeded 1.00 during the first period and was less than 1.00 in the succeeding two periods. Finally, for the comparison of wholesale prices in Chicago and New York City for Michigan-grown onions, both the regression slope and the correlation coefficient declined in succeeding time periods.

Annually: Michigan f.o.b.–Michigan, Chicago Wholesale

The results obtained from regressing the Michigan f.o.b. shipping point price on the Michigan wholesale price in Chicago for each year are shown in table 25 for selected crop years from 1930 to 1967. The years not shown are World War II and those years during which futures trading existed but at a relatively low level. The rationale for the direction of causality implied by the regression used here is that price-making forces work themselves out in the terminal market and the "information" generated is passed back through the marketing system to the primary producing region. This is another way of saying that the demand at the shipping point level is derived from the demand at the terminal market.[42]

For the 29 years shown in table 25, 18 years had a confidence interval which included the value of 1.00. In other words, in nearly two-thirds of the years considered, the market operated as predicted by the

[42] See chapter 9.

perfectly competitive model. Whether or not this is sufficient frequency to permit the general conclusion that this market has operated perfectly over space during the time period under consideration is a matter of personal judgment.

Some difference, although slight, emerges when three subperiods are considered separately. During 1930-40, 7 years, or 64 percent, had confidence intervals which included the value of 1.00. For the other two periods the corresponding percentages were 67 and 52, respectively.

The second factor to consider in evaluating the performance of the market is the correlation coefficient, or the R^2, shown in the last column of the table. On the basis of the theory, we would expect this coefficient to be close to 1.00, indicating that the two prices move in close correspondence. With this as a reference point, for 15 of the 29 years or slightly over 50 percent, the correlation coefficient had a value of less than 0.85. In fact, for 7 of the 29 years, or almost 30 percent, the correlation coefficient had a value of less than 0.65, which means that during these years considerably less than two-thirds of the variation in the Michigan f.o.b. shipping point price was associated with variation in the Michigan wholesale price at Chicago. While there is no definitive criterion against which to evaluate results such as these, the rather large frequency of low values for the correlation coefficient provides a basis for seriously questioning the degree to which this market performed according to the competitive norm. However, one must keep in mind the earlier discussion concerning possible reasons why real-world markets may fail to perform in this fashion.

Substantial variation in the distribution of the correlation coefficient occurs among time periods. In 1930-40, 6 of the 11 years or slightly over 50 percent,

Table 25.—Onion prices: Summary of regression results with Michigan f.o.b. shipping point price as dependent variable and Michigan wholesale price at Chicago as independent variable, weekly prices for weeks with prices for both series, selected crop years, 1930-67

Crop year	Estimated regression slope	95 percent confidence interval	Inverval includes value of 1.00	R^2
1930	0.52	0.28-0.76	No	0.40
1931	1.00	.90-1.10	Yes	.95
1932	1.23	.55-1.91	Yes	.34
1933	.92	.82-1.02	Yes	.92
1934	1.07	1.03-1.11	No	.99
1935	1.18	.92-1.44	Yes	.76
1936	1.07	.83-1.31	Yes	.73
1937	.99	.77-1.21	Yes	.79
1938	.41	.17- .65	No	.38
1939	1.32	1.06-1.58	No	.89
1940	1.05	.93-1.17	Yes	.96
1949	.87	.73-1.01	Yes	.92
1950	1.20	.48-1.92	Yes	.32
1951	.99	.89-1.09	Yes	.93
1952	.92	.80-1.04	Yes	.90
1953	.69	.53- .85	No	.72
1954	.86	.72- .98	No	.88
1955	.76	.64- .88	No	.87
1956	1.24	.98-1.50	Yes	.77
1957	1.11	.99-1.23	Yes	.93
1959	.75	.67- .83	No	.91
1960	.98	.76-1.20	Yes	.77
1961	1.00	.96-1.04	Yes	.99
1962	.96	.72-1.20	Yes	.70
1963	.82	.52-1.12	Yes	.51
1964	.88	.78- .98	No	.93
1965	.64	.42- .86	No	.60
1966	1.00	.68-1.32	Yes	.62
1967	1.30	1.08-1.52	No	.84

Table 26.—Onion prices: Summary of regression results with Michigan f.o.b. shipping point price as dependent variable and New York f.o.b. shipping point price as independent variable, weekly prices for weeks with prices for both series, selected crop years, 1930-67

Crop year	Estimated regression slope	95 percent confidence interval	Interval includes value of 1.00	R^2
1930	0.79	0.68-0.90	No	0.67
1931	1.04	.98-1.10	Yes	.98
1932	No data	No data	No data	No data
1933	.93	.83-1.03	Yes	.93
1934	1.00	.98-1.02	Yes	.99
1935	1.03	.91-1.15	Yes	.92
1936	1.24	1.07-1.41	No	.87
1937	1.04	.96-1.12	Yes	.96
1938	.82	.71- .93	No	.87
1939	.90	.87- .93	No	.99
1940	.70	.64- .76	No	.94
1949	.95	.85-1.05	Yes	.95
1950	.88	.81- .95	No	.96
1951	.98	.94-1.02	Yes	.99
1952	.98	.91-1.05	Yes	.97
1953	1.10	.82-1.38	Yes	.69
1954	.80	.57-1.03	Yes	.64
1955	1.26	1.18-1.34	No	.97
1956	.98	.84-1.12	Yes	.89
1957	.85	.78- .92	No	.96
1959	1.28	1.14-1.42	No	.92
1960	.71	.62- .80	No	.91
1961	.97	.93-1.01	Yes	.99
1962	.87	.72-1.02	Yes	.83
1963	.65	.45- .85	No	.60
1964	1.41	1.07-1.75	No	.72
1965	.70	.59- .81	No	.63
1966	1.14	.98-1.30	Yes	.88
1967	.93	.88- .98	No	.98

had coefficients less than 0.85. On the other hand, only 3 of 9, or 33 percent, of the years in 1949-57 had such low coefficients. In the last period, 1959-67, 6 years, or 67 percent, had coefficients of less than 0.85, indicating that during this period very little of the f.o.b. price was explained by changes in the terminal market price on a year-to-year basis.

Annually: Michigan f.o.b.—New York f.o.b.

In the previous comparisons, there was some theoretical basis for specifying the causal nature of the regression equation; namely, the notion of derived demand suggested that demand at shipping point is a function of demand at the terminal market. In the current case, f.o.b. shipping point prices are used. There is no theoretical basis for selecting which way to conduct the regression analysis—one might think that the regression slope would be the same regardless of which way the regression is run but such is not necessarily the case.[43] In the absence of a better argument, it was arbitrarily decided to regress the Michigan price on the New York price.

The results of these regressions for selected years are presented in table 26. For the total period, the confidence interval includes the predicted value 1.00 in 14 of the 28 years (no data were available to do the regression for the 1932 crop year). Thus, for only one-half of the time did this market perform in accordance with the competitive norm. As was the case in the previous evaluation, there is no basis for drawing any conclusion concerning the overall competitiveness of this market. However, such a low frequency of years of performance as predicted is a source of concern.

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[43] See chapter 9.

Considerable variation in frequency of competitive performance exists among the three subperiods. For the first period, 5 of the 10 years had confidence intervals which included the predicted value of 1.00. The frequency of performance according to the competitive norm was higher during 1949-57, when 6 of the 9 years, or 67 percent, had confidence intervals which included a value of 1.00. The opposite was the case for 1959-67; the market performed according to the competitive norm in only 3 of the 9 years, or 33 percent.

While the regression slope for many of the years differed considerably from expectations, the correlation coefficients obtained were closer to expectations. For 12 of the 28 years, this coefficient was 0.95 or higher; it was equal to 0.90 or higher for 17 of the 28 years. At the other end, it was less than 0.85 in only 7 of the 28 years. Again, there was considerable variation among the subperiods. The frequency of a coefficient of less than 0.85 was 1 out of 10 in 1930-40, 2 out of 9 in 1949-57, and 4 out of 9 in 1959-67, suggesting a tendency for a decline over time in the degree to which these prices tended to move together.

Lagged Regressions

In the introductory section, several factors were mentioned that could cause actual price performance to deviate from that expected on the basis of theory. One of these factors involves the time required for information to flow among markets. A crucial assumption of the theory used as an analytical framework in this chapter is that complete information is instantaneously available to all market participants. This assumption is required in the theory in order that responses to price changes may be made immediately, so that the commodity flow will be redirected to maintain the proper relation among the prices in the various markets.

In real-world markets, it is quite unlikely that changes in conditions in one market will be immediately known by traders in other markets. Time, no matter how slight, is required for information to flow over space. More specifically, it is conceivable that some time will elapse before a change in the f.o.b. shipping point price in Michigan will change in response to a change in the wholesale price at Chicago. How much time is actually required is, of course, a matter for empirical investigation. With the data available, a crude attempt was made to evaluate this question using the price series just mentioned. Regressions were estimated for each year over the entire period, with the Michigan f.o.b. price in 1 week dependent on the Chicago wholesale price of the previous week. The simple assumption here is that there is a 1-week lag in the response of the f.o.b. price to the wholesale price.

The results of these regressions are not presented because no significant results were obtained. Using the standard evaluative criteria, there appeared to be no relationship when using lagged prices. One cannot conclude from this, however, that a lag does not exist, but only that it cannot be detected using weekly prices. A more rigorous consideration of this important question would use daily, perhaps within-day, prices. Unfortunately, such data were not available for the current study.

CHAPTER 9. SOME STATISTICAL CONSIDERATIONS

When using regression analysis to study the price relations among actual markets, as was done in chapter 8, it is necessary to impute causality; it is necessary to view price in one market as being dependent on the price in another market. Unfortunately, by the process used to estimate the coefficients of the regression equation, it is possible to obtain quite different results from the two alternative formulations. With one price series placed in the dependent position, it would be possible to conclude that the market has operated under competitive conditions but to reach the opposite conclusion if the other price had been placed in the dependent position. This seeming inconsistency arises from the statistical characteristics of the price series used. The problem is not necessarily related to the economic theory but rather to the statistical properties of the data used to estimate the relations specified by the theory.

The purpose of this chapter is to determine the extent to which the results shown in chapter 8 are affected by this statistical question. The next section outlines the problem. The subsequent two sections assess the effect of the problem on the estimates obtained for the seven different market comparisons when the years were grouped into three separate periods, and for the results obtained when comparing the Michigan f.o.b. price and the Michigan, Chicago wholesale price on a year-to-year basis.

The Statistical Problem

Consider any two variables, X and Y, where each may be placed in the dependent position to obtain the following two regression equations:

$$(1) \quad X = a_y + b_y Y$$

$$(2) \quad Y = a_x + b_x X$$

Equation (1) says to regress X on Y to obtain b_y; equation (2) says to regress Y on X to obtain b_x, where exactly the same set of data is used in both regressions. The statistical question becomes: is b_y equal to b_x?

To answer this question we need some notation.

Let:

S_x = the standard deviation of X

S_y = the standard deviation of Y

r = the simple correlation coefficient between X and Y.

It can be shown that

$$(3) \quad b_y = r\frac{Sx}{Sy}$$

and

$$(4) \quad b_x = r\frac{Sy}{Sx}$$

Multiply (3) by (4) to obtain

$$(5) \quad b_y b_x = r^2 \frac{Sx}{Sy}\frac{Sy}{Sx} = r^2$$

which, on dividing both sides by b_x, yields:

$$(6) \quad b_y = \frac{r^2}{b_x}$$

This is an important result because it shows that in the case of perfect correlation, i.e., r = 1, the coefficient obtained from regressing X on Y is the reciprocal of the coefficient obtained from regressing Y on X.

In the context of the perfectly competitive market in space, we expect the coefficient obtained from regressing one price on another to be equal to 1.00. The theory implies that it makes no difference which way the regression is run. However, equation (6) shows that a value of 1.00 will be obtained from the two different regressions only under a very special condition, namely, when the correlation between the two price series is perfect. To state the alternative, and more likely, case when the correlation coefficient, r, is less than 1.00, then the regression results will be different depending on which price is placed in the dependent position. In such a case, quite different conclusions could be drawn concerning price performance. As an extreme illustration, suppose the Michigan f.o.b. price is regressed on (is placed in the dependent position) the Michigan wholesale price and a regression coefficient of 1.00 is obtained. Since this is in accord with the relevant theory, one would conclude that competitive conditions were operating in this market. But, if the correlation coefficient were 0.5, equation (6) tells us that if we had reversed things and regressed the wholesale price on the f.o.b. price we would have obtained a regression coefficient of 0.50. What does one now conclude?

In the following two sections, comparisons like these are made for the various regressions discussed in chapter 8. To facilitate these comparisons, the tables below show the 95 percent confidence intervals associated with the two ways of running the regressions. Thus, it will be possible to examine not only whether the regression coefficient is statistically different from 1.00 but also, for those cases where it is different, to judge whether it is greater than or less than 1.00.

All Market Comparisons—Groups of Years

The comparisons of the regression results using the alternative formulations are shown in table 27, where the first column reproduces the results shown in chapter 8 and the second shows the results with the positions of the respective prices reversed.

The first two sets of comparisons involve the Michigan f.o.b. price with the wholesale price for Michigan onions in Chicago and New York City, respectively. With the initial equations, where the f.o.b. price is in the dependent position, the confidence interval for 1949-57 includes 1.00 for both the Chicago and New York City wholesale markets, the expected result based on the competitive model. In the first period, the confidence interval lies above 1.00 for both wholesale markets, but for the third period it is above for the Chicago market and below for the New York City market. Thus, the results for the first and third periods fail to conform to the competitive norm. On the other hand, for both markets and for all periods the confidence interval lies below 1.00 when the wholesale prices are placed in the dependent position. In other words, when the positions of the respective prices are reversed no results are obtained that conform to the competitive norm.

For both market comparisons in all three periods, the Michigan f.o.b. price had a greater degree of variation than either of the wholesale prices, as shown by the ratio of the standard deviations. Integrating this with the observations made above reveals the following pattern. When the price with the greater variation, the f.o.b. price, is placed in the dependent position, the confidence interval lies above 1.00 in three comparisons, includes it in two comparisons, and lies below it in one. On the other hand, when this price is placed in the independent position and the wholesale price with lesser variation is placed in the dependent position, the confidence interval lies below 1.00 in all six comparisons. From a statistical standpoint, this result is a manifestation of the relationships derived in the previous section. It illustrates the sensitivity of the regression results to the variation in the two price series and to which price is placed in the dependent position for the regression analysis. From an economic standpoint, this result, in effect, leaves unanswered the question of whether competitive conditions existed in these markets, because conflicting conclusions are drawn depending on which one of the regression formulations is considered.

If one restricts himself strictly to the competitive model being used here, then there is no apparent way to resolve this conflict. However, where the relation between f.o.b. and wholesale prices is involved, it may be possible to develop a partial resolution using the following line of reasoning. In theory, the observation that prices in all markets are determined simultaneously is not too difficult to accept. However, in real-world markets this simultaneity may be difficult to achieve due to such things as time lags involved in information flow and in market participants' response to changing conditions.[44] In addition, it is quite likely that changing market conditions will be first experienced at that point in the marketing system nearest to the final consumer, the wholesale market in this case. Consequently, when examining the relation between f.o.b. and wholesale prices there is some justification for viewing the f.o.b. price as "dependent" on the wholesale price. This line of reasoning would argue for the use of the initial regressions in assessing the price performance of the Michigan f.o.b.-wholesale sector of the onion market. In this case, the results presented in table 1 would substantiate the conclusion that competitive conditions existed during 1949-57 for both wholesale markets but did not exist during the other two periods with respect to either wholesale market.

Two additional comparisons involving f.o.b. and wholesale prices are shown in table 27, New York and Texas. Exactly the same pattern as observed above is seen here. When the f.o.b. price has a greater degree of

[44] This line of reasoning quickly leads to the use of lagged regressions. This was considered in chapter 8 and the conclusion there was that if lags are present they would not be detected using the weekly data available.

Table 27.—Comparison of 95 percent confidence intervals obtained by placing prices alternatively in dependent position in simple regression, seven market comparisons, selected periods, 1930-67

Item	95 percent confidence interval when dependent price is—[1]		Ratio of standard deviation of prices[2]	R^2
	left of colon	right of colon		
Mich. f.o.b.: Mich., Chi., Whlse				
1930-1940	1.02-1.07	0.90-0.94	1.07	0.97
1949-1957	.98-1.05	.89- .95	1.05	.94
1959-1967	1.01-1.08	.86- .92	1.08	.93
Mich. f.o.b.: Mich., NYC Whlse				
1930-1940	1.04-1.09	.88- .93	1.09	.97
1949-1957	.96-1.02	.93- .99	1.02	.95
1959-1967	.83- .97	.81- .96	1.01	.80
Mich. f.o.b.: NY f.o.b.				
1930-1940	1.01-1.03	.95- .98	1.03	.99
1949-1957	.92- .97	1.01-1.05	.96	.97
1959-1967	.92- .97	1.00-1.04	.96	.97
N.Y. f.o.b.: NY, NYC Whlse				
1930-1940	1.05-1.07	.91- .94	1.07	.98
1949-1957	.99-1.05	.90- .96	1.05	.96
1959-1967	.85- .93	.95-1.04	.95	.88
Mich., NYC Whlse.: NY, NYC Whlse				
1930-1940	1.02-1.06	.93- .97	1.05	.98
1949-1957	.93-1.00	.93-1.00	1.00	.94
1959-1967	.79- .92	.86-1.01	.96	.80
Mich., Chi. Whlse.: Mich., NYC Whlse				
1930-1940	.97-1.03	.93- .98	1.02	.95
1949-1957	.88- .98	.92-1.01	.98	.89
1959-1967	.77- .89	.91-1.05	.92	.82
Texas f.o.b.: Texas, NYC Whlse				
1930-1940	.63- .77	1.17-1.42	.73	.91
1949-1957	.86-1.05	.81- .99	1.03	.86
1959-1967	.75- .90	.97-1.16	.88	.88

[1] Confidence interval should include the value of 1.00 if market is operating under competitive conditions.
[2] Ratio of standard deviation of price on left of colon to standard deviation of price on right of colon.

variation than the associated wholesale price and when it is placed in the dependent position, the resulting confidence interval either lies above 1.00 or it includes this value. When the wholesale price is placed in the dependent position the confidence interval lies below 1.00. These two comparisons provide additional insights into the problem. In both cases there were periods during which the f.o.b. price varied less than the associated wholesale price. For those periods, when the f.o.b. price is placed in the dependent position the resulting confidence interval lies below 1.00; when the wholesale price is dependent the confidence interval lies above or includes this value.

As with the analysis of the Michigan price relations, conflicting results emerge. However, if the same line of reasoning is employed here, namely that there is some justification for viewing the f.o.b. price as dependent, then the same conclusion emerges. In both cases, competitive conditions existed during 1949-57 but did not exist during either of the other two periods.

The three other comparisons presented in table 1 involve prices at the same level in the marketing system: Michigan and New York f.o.b.; Michigan and New York onions in the New York City wholesale market; and Michigan onions in the Chicago and New York City wholesale markets. Again the sensitivity of the results to the statistical properties of the price series is apparent: When the price with the greater variation is viewed as dependent the confidence interval tends to lie above or include 1.00; when it is viewed as independent the interval lies below. There is no immediately obvious ad hoc argument to resolve the apparent conflict as there was above. However, a cursory examination of the separate comparisons is suggestive.

Table 28.—Comparison of 95 percent confidence intervals obtained with Michigan f.o.b. price dependent and with Michigan, Chicago wholesale price dependent, selected years, 1930-67

Year	95 percent confidence interval when dependent variable is—[1]		Ratio of standard deviation of prices[2]	R^2
	Michigan f.o.b. price	Michigan, Chi. wholesale price		
1930	0.28-0.76	0.85-1.57	0.82	0.40
1931	.90-1.10	.89-1.07	1.02	.95
1932	.55-1.91	.33- .62	2.13	.34
1933	.82-1.02	.89-1.17	.89	.92
1934	1.03-1.11	.89- .97	.93	.99
1935	.92-1.44	.59- .89	1.35	.76
1936	.83-1.31	.64- .95	1.25	.73
1937	.77-1.21	.72-1.06	1.12	.79
1938	.17- .65	.96-2.04	.67	.38
1939	1.06-1.58	.58- .84	1.40	.89
1940	.93-1.17	.82-1.04	1.07	.96
1949	.73-1.01	.94-1.26	.91	.92
1950	.48-1.92	.31- .64	2.10	.32
1951	.89-1.09	.88-1.06	1.03	.93
1952	.80-1.04	.92-1.15	.97	.90
1953	.53- .85	.99-1.48	.81	.72
1954	.72- .98	.95-1.24	.91	.88
1955	.64- .88	1.06-1.40	.82	.87
1956	.98-1.50	.57- .84	1.42	.77
1957	.99-1.23	.77- .96	1.15	.93
1959	.67- .83	1.23-1.30	.79	.91
1960	.76-1.20	.73-1.07	1.11	.77
1961	.96-1.04	.95-1.04	1.00	.99
1962	.72-1.20	.69-1.05	1.15	.70
1963	.52-1.12	.64-1.10	1.15	.51
1964	.78- .98	.98-1.21	.91	.93
1965	.42- .86	.91-1.53	.82	.60
1966	.68-1.32	.60- .98	1.27	.62
1967	1.08-1.52	.59- .81	1.42	.84

[1] Confidence interval should include the value of 1.00 if market is operating under competitive conditions.
[2] Ratio of standard deviation of Michigan f.o.b. price to standard deviation of Michigan, Chicago wholesale price.

For the Michigan and New York f.o.b. prices, the confidence interval lies above or below 1.00, depending on which is dependent, for the first two periods. For 1959-67, the interval includes 1.00 when the price with the greater variation is placed in the dependent position. Viewing these results in total it appears that performance is not in accord with the competitive norm.

A similar relationship exists for Michigan and New York onions in the New York City wholesale market. For 1930-40, the confidence interval lies above 1.00 for one regression and below for the other. For 1949-57, it includes 1.00 for both regressions; in this period the variation in the two price series was the same. Finally, the confidence interval includes 1.00 for 1959-67 when the price with the greater variation is placed in the dependent position.

The last comparision involves the price of Michigan onions in the Chicago and New York City wholesale markets. For each of the three periods, the confidence interval includes 1.00 when the price with the greater variation is placed in the dependent position.

Michigan F.O.B. Price—Chicago Wholesale Price

The comparisons of the Michigan f.o.b. price with the Chicago wholesale price on a year-to-year basis are shown in table 28. As in the previous section, the first column reproduces the results shown in chapter 8 and the second column shows the results obtained when using the wholesale price in the dependent position.

For 11 of the 29 years, the confidence interval includes the value of 1.00 regardless of whether the f.o.b. or wholesale price is viewed as dependent. There was a tendency for the variation in the two prices to be about the same during each of the years considered; the average ratio of the standard deviation for the 11 years is 1.04. However, considerable variation in the ratio exists, ranging from a low of 0.89 in 1933 to a high of 1.15 in 1962 and 1963. Of the 11 years involved, there were 8 where the f.o.b. prices varied more and 3 where the wholesale price varied more.

In 8 years, the confidence interval lies below 1.00 when the f.o.b. price is dependent. Of these, 6 years with the wholesale price dependent yield a confidence interval that includes 1.00 and 2 with an interval above 1.00. In all 8 years, the wholesale price varied more than the f.o.b. price. The average ratio of the standard deviation was 0.80.

Finally, there are 10 years where the confidence interval lies below 1.00 when the wholesale price is dependent. For 7 of these, the interval includes 1.00 when the f.o.b. price is dependent and for 3 the interval is above 1.00. In all 10 cases, the f.o.b. price varied considerably more than the wholesale price. In summary, the pattern observed in the previous section is also observed here. When the amount of variation in the two prices is approximately the same, then the confidence interval includes the value of 1.00 regardless of whether the f.o.b. or the wholesale price is placed in the dependent position. When the f.o.b. price has less variation and is placed in the dependent position, the confidence interval tends to lie below the value of 1.00. Similarly, when the wholesale price varies more and is placed in the dependent position, the confidence interval tends to lie above 1.00.

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